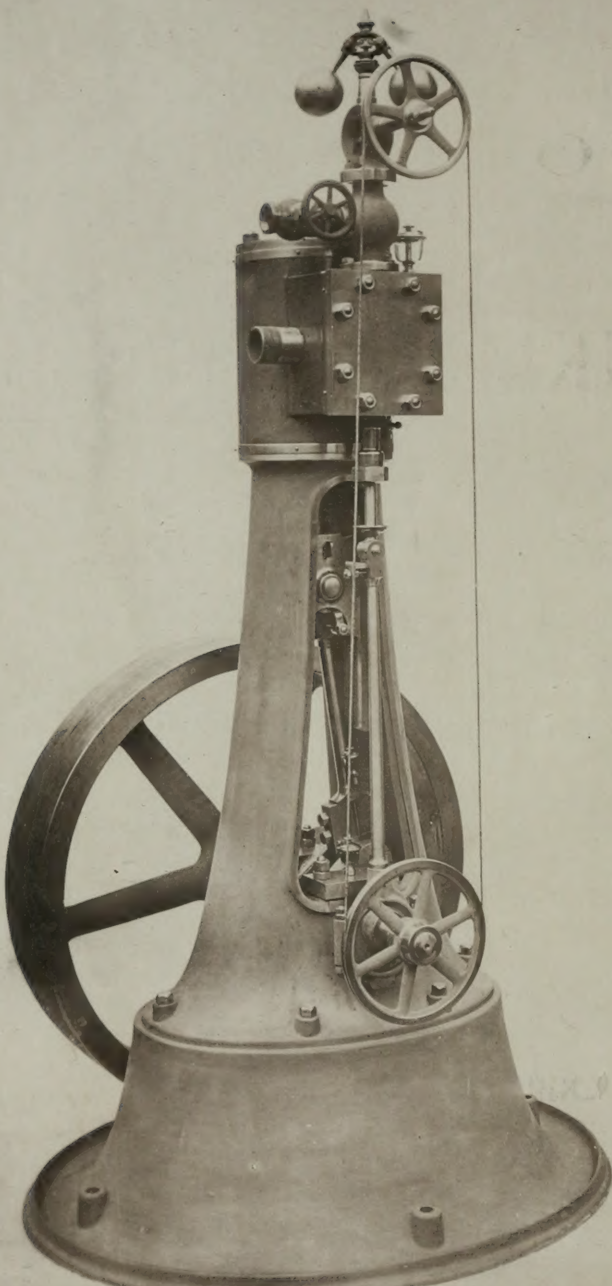

Photo-Plate by Rehn & Dickes

VERTICAL ENGINE.

BUILT AT THE PEOPLES WORKS. PHILADELPHIA.

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THE

JOURNAL

OF THE

FRANKLIN INSTITUTE

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

WILLIAM H. WAHL, PH. D.,

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FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LXIII.] JANUARY, 1872. No. 1

EDITORIAL.

ITEMS AND NOVELTIES.

Vertical Engine.—The vertical engine shown in full-page photo-plate, by Rehn, was designed by the writer and is built by Jacob Naylor, at the People's Works, corner of Front street and Girard avenue, Philadelphia.

The base is oval in plan, with rim all around for retaining drippage from engine: on this stands a column with oval foot, bolted to the base, and with circular closed top, to which the cylinder is bolted. This column is open vertically fore and aft, to give access to all the working parts; at the lower part are formed in the casting pedestals for the shaft bearings, at the middle part the guides, and at the top the piston-rod stuffing-box, which is a separate piece, bolted in and projecting downwards to the top of the openings, the upper end of the column forming the lower cylinder head.

The crank shaft is of McHaffie steel, with counterbalance cast on, in the smaller sizes, and of best hammered iron in the larger. The fly-wheel pulley overhangs the rear bearing, which is made very long, and the rear end of fly-wheel hub is made short, so that the center of mass of wheel is well supported. The eccentric and governor pulley overhang the front bearing. In the larger sizes it is proposed to sup-

port the rear end of shaft in a third bearing, secured to an extension of the base carried around the fly-wheel.

The piston is made like Carlsund's, and is supplied with the Ramsbottom steel rings. The valve is a plain D slide. The cross-head is fitted with adjustable wooden gibs. The shaft and connecting-rod bearings (provided with compensation for wear), and the piston-rod and valve-rod stuffing-boxes and holding-nuts on valve-rod, are of copper and tin composition. The connecting-rod, piston-rod and valve-rod are of steel. The cylinder and steam-chest are clothed with wood and cased with Russia sheet iron, held by polished bands. Drip pipes and cocks are supplied to the lower ends of cylinder and steam chest, and self-acting oil-cups to shaft and connecting-rod bearings. The steam and exhaust-pipes can be applied to either side of engine, thus making it at once right or left.

The governor is of the simplest centrifugal kind, with brass-balanced valve, and every working part of the engine is simple, strong, readily accessible and easily repaired and replaced.

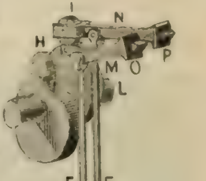
The engine as a whole is neat and graceful in appearance, occupies little space, needs no expensive foundation, is self-contained, is capable of quick movement, is not liable to derangement with ordinary attention, and is believed to combine all the modern improvements of which the single slide-valve steam-engine, without independent cut-off or condensing apparatus, is capable.

The plan of engine, however, allows the introduction of independent cut-off valve, as the Rider patent, for instance, which is the simplest and best, and of course the cheapest, since it consists simply of the addition of one eccentric and rod, one valve stem guide and swivel, and one slide-valve, of peculiar yet simple construction, working on back of main slide, but with no liberating and arresting gear. It is proposed to apply this cut-off to the larger sizes where the saving of fuel would warrant its introduction. J. H. COOPER.

An Equable Pump, *or Machine for Raising Water without Interruption or Concussion.*—"It is composed of two barrels, A B, both of them forming part of the column of water to be raised, connected together by a crooked tube, C, of equal diameter, out of which the lower piston-rod passes through a stuffing-box into the air, as does the upper piston-rod at D, where the column leaves the pump to pass upward. The two pistons fixed to the rods E and F are of the bucket kind, made as thin and light as possible, their valves opening upwards, and their motions being such, generally, that when one of

them is drawn up the water rises through the other, then descending. But here lies both the novelty and utility of the machine; these up-upward and downward motions are not reciprocal. Both pistons fall faster than they rise, and thus leave an interval of time, *when they both rise together*, during which their valves, respectively, close by their own weight *before* the column of water falls upon them; in such manner, indeed, that the column never *falls* at all. By this important arrangement the work is constantly going on, and *no commotion* occurs to absorb *power* uselessly, or to destroy, prematurely, the machine—circumstances which constantly attend every pump machine acting by merely reciprocal motion.

This non-reciprocity, then, I produce by several methods, one of which (perhaps the most easily understood) is that shown in the cut:



"Thus, H I are two friction-rollers, made as large as possible, rolling on pins in the ends of the levers M N, to which the bucket rods, E F, are attached, and tenons on the other ends hold these ends stationary in mortices, and on the curves J K, the ascending and descending parts of which are essentially *unequal*. For example, the rising part of the curve occupies $\frac{2}{3}$ of the whole circumference, and the falling part $\frac{1}{3}$ only; so that both curves recede from the center at the same time, during $\frac{1}{6}$ of a revolution.

"Applying, then, these curves and levers to the pump-barrels, we obtain that *continuity of uniform* motion which is necessary to doing the greatest quantity of work with the least power, and to securing the greatest durability of the machine. Having hinted at a *minimum* of power, I must add here that this machine appears to promise that result, much more credibly than any reciprocating pump whatever, especially if to this continuity of motion we add a certain *largeness* of dimension that shall produce the required quantity of water with the slowest possible motion of each particle; and even here this *continuative* principle helps us much, since pistons and valves of the largest dimensions may be used without introducing any convulsive or (what is synonymous) any destructive effects.

"One particular remains to be noticed. It relates to the means by

which the *perpendicularity* of the motion in the piston-rods is secured. The arcs, O P, are portions of cylinders having the centers of the pump-rod connections in the levers for their centers, and which, *rolling* up and down against the perpendicular plane into which the end tenons fit, secure a vertical motion to the pump-rods.

"It should be observed that the present machine was executed in France in 1793 or 1794, and also proposed to the government as a substitute for the celebrated machine of Marly. In the report then published it was preferred to the whole multitude of former projects."—*Century of Inventions.* James White. 1822. J. H. C.

An Inclined Horse-Wheel.—"My principal inducements for giving this wheel the form represented by a section were to save *horizontal room* and to gain speed by *a wheel* smaller than a common horse-walk, and yet requiring less obliquity of effort on the part of the horse.

"With this intention the horse is placed *in a conical* wheel, A B, more or less inclined, and not much higher than himself, where, nevertheless, his head *is seen* to be at perfect liberty out of the cone, as at C. The horse then walks *in* the cone, and is harnessed to a fixed bar introduced from the open side, where, by a proper adjustment of the traces, he is made to act partly by his weight, so as to exert his strength in a favorable manner. This machine applies with advantage where a horse's power is wanted *in a boat or other confined place;* and it is evident, by the relative diameters of the wheel and pinion, A B and D (as well as by the small diameter of the wheel), that a considerable velocity will be obtained at the source of power, whence, of course, the subsequent *gearing* to obtain the swifter motions will be proportionately diminished."—*Century of Inventions.* James White. 1822. J. H. C.

Utilization of Coal-Dust.—Mr. E. Loiseau, of Philadelphia, recently submitted to the Institute samples of blocks and balls of bituminous and anthracite slack; made by thoroughly mixing with the fine coal about seven per cent. of clay; the object of the inventor being to present a cheap method of utilizing the immense quantities of waste or slack, which are the attendants upon mining

operations—an idea which has already called forth a number of inventions.

The lumps prepared, as already stated, are dipped into a bath of benzine, in which rosin has been dissolved. The object of this operation is to render them impervious to moisture. The solution penetrates the lumps to the extent of about a quarter inch ; and upon the evaporation of the benzine, which takes place rapidly upon exposure to a current of air, a film of rosin is left behind, which so effectually stops up all crevices, that in the experiments made by the Committee on Science and Arts in investigating the process, masses which had lain in water for twelve hours were found to have lost none of their compactness and to be still dry in the interior. The consumption of the artificial fuel took place very satisfactorily, all the specimens burning till completely ashed.

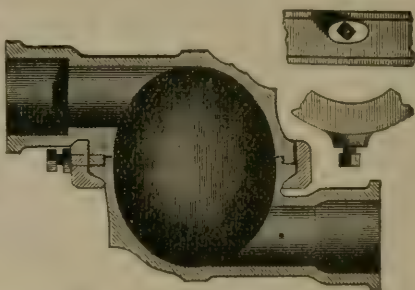
With regard to the heating power of the material, the committee's report show this to be somewhat below the average of bituminous or anthracite, as would naturally be anticipated from the admixture of clay. The compactness of the material will, in their opinion, allow of its transportation, with ordinary handling, with as little loss from breakage, as is suffered by many kinds of bituminous and semi-bituminous coals which are brought to market.

It would seem, therefore, that the plan of Mr. L. is one of the most practical which has yet been made public for utilizing this waste product. Its ability to withstand disintegration by the action of rain is certainly a great point in its favor. The main question after all, however, resolves itself into one of economy, and it is clear that, however well adapted it may be for many purposes in the arts, no artificial fuel can ever become of practical value to consumers, until the cost of its preparation is less expensive than the cost of mining coal. Should this prove to be the case with the plan here described, it will doubtless prove in every way worthy of the attention of those interested in the production of a cheap fuel.

The Patent Diamond Drill is a tube of iron, like gas pipe, the lower end of which is faced with small diamonds. The drill generally stands upright, but may be used in other positions. We speak here of the vertical drill. The drill is revolved rapidly by steam machinery, and is fed downwards into the rock by a screw-feed, somewhat in the manner of a drill in an ordinary drilling press used in machine shops. The hole cut by the drill is a *ring*, leaving a *core* standing inside of the tube. To prevent heating by friction, a con-

stant stream of water is forced down the inside of the tube, and reascends outside, bringing up the dust or borings. The steam engine used to actuate the drill resembles in general appearance an ordinary portable steam hoisting engine. The cylinders and the machinery are bolted to the vertical face of the end of the boiler. The apparatus for turning the drill, feeding, and causing the drill to return out of the hole when desired, is ingenious and effective, but need not be minutely described here. The writer saw a two-inch hole put down about two feet into hard rock, perhaps at the rate of four feet per hour. The diamonds are said to last a long while, and to be self-sharpening. The hole, for small holes, may be about three-quarters of an inch more in diameter than the core; in large holes the difference is probably somewhat greater, but the proportion of the diameters more nearly equal. The core of small holes breaks off by raising the drill, and there is an ingenious and effectual method of causing the core to come up with the tube when the tube is withdrawn from the hole. It is said that large cores are broken loose at the bottom by means of blasting, the cartridge being sent down the hollow ring left by the drill. J. W.

Steam-Pipe Joint.—We subjoin an engraving showing a neat form of flexible joint for steam-pipes, designed by Messrs. Wöhrman & Son, of Mülenhof, Russia, and which has been successfully employed by them for the pipes of steam pile-driving machines.



In spherical joints, as ordinarily constructed, the pressure tends naturally to force apart the surfaces which fit together, and which form the steam-tight joint.* In the engraving here illustrated this action is reversed, the pressure of the steam tending to force the joint surfaces together.

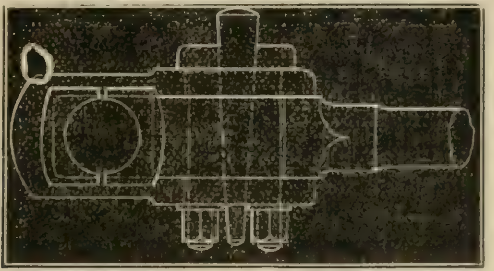
The illustration herewith presented explains the construction and operation so clearly that a further description is unnecessary. The joint is declared to answer well, and there are many situations where it could doubtless be usefully applied.

* English Mechanic, xiv, 246.

Light Railways*.—A wooden railway, four feet eight and one-half inch gauge, is being constructed in the province of Quebec, Canada. The rails are of maple, four by seven inches, and fourteen feet long; the ties are of hemlock and tamarac.

The cost of the line, thirty miles long, including nine stations, car and locomotive depot, engine and repairing shops, engine and tender, two passengers cars, eight grain cars and twenty-five wood cars, is $5,000 a mile, including all damages.

An experimental trip has been made on the completed portion of the road, the train going at the rate of twenty-five miles an hour and with remarkable smoothness.



Improvement in Stub-ends.—The above cut represents the stub end as designed by Mr. John Fritz, for the large engines he is making for the Bessimer plant of the Bethlehem Iron Co., at their works at Bethlehem, Pa. The cut explains itself. It may be observed that the gibs used in each side of the key, are made with heads which project side-ways as well as end-ways, and the washers and nuts at the lower end of gibs also cover as much surface on the strap as do the heads. The gibs are, in fact, through bolts, and while they answer the purpose for which they are required, they serve to bind the strap firmly to the stub end, and prevent the loosenesss from wear consequent upon the use of gibs as ordinarily made. This practice of Mr. Fritz, seems to have all the merit of the through bolts as used by locomotive engineers, and the gib and key as used on stationary engines. COLEMAN SELLERS.

A Hard Cement.—The Abbe Moignot† relates a circumstance which may contain a valuable hint in relation to the use of cement. A workman employed to repair the steps leading to a garden, made use of Portland cement mixed with finely divided cast and wrought

*Technologist, Dec., 1871.
† Les Mondes.

iron filings, or fragments, in place of sand. The result is stated to be, that the mass has become so hard as to resist fracture, either with the hammer or pick-axe.

A Novel Patent.—As a substitute for gunpowder, J. Fournier has patented, in England, the following curiosity: 125 grms. carbonate of lime; 65 grms. salt; 35 grms. of charcoal and as much wine as is necessary to cover these materials in a vessel.

The attention of our readers is invited, in this connection, to the very sensible remarks of Mr. J. Richards upon the subject of patents. Surely no better argument for the necessity of thorough reformation of the system of patent laws could be desired than is afforded by the possibility of the committal of a blunder so glaring as the patenting of an "invention" so palpably and laughably absurd as this.

Welding Copper*.—A mixture composed of 358 parts of phosphate of soda and 124 parts of boracic acid is recommended by Mr. Rust as an admirable one to insure the perfect welding of copper.

The powder should be applied while the metal is at a dull red heat; it is then brought to a cherry-red and at once hammered. Owing to the tendency of the metal to soften after exposure to a high heat, a wooden hammer is recommended which is to be applied very gently. All carbonaceous matter must be carefully removed from the faces to be joined, since the principle of the operation depends on the formation of a very fusible phosphate of copper, which would be reduced by carbon to the condition of a phosphide. The action of the substance recommended depends upon the ability of the phosphate of copper formed, to dissolve the thin film of oxide on the surfaces of metal, keeping them thus perfectly clean and in condition to weld.

A New Hygrometer.†—Mr. Woodbury proposes to utilize the color changes which, as is well known to chemists, are produced in the chloride of cobalt on exposure to different degrees of moisture, for the purpose of hygrometric measurement. For this purpose the inventor treats sized paper with a strong solution of chloride of cobalt, to which has been added a small quantity of common salt and gum arabic. This will retain a blue color in a dry atmosphere, but will change through all the gradations to pink, as the air becomes moist to damp. In order to construct a scale for reading these indications, the inventor draws on a card two circles, one considerably

* Am. Ex. and Review, Dec., 1871.
† English Mechanic, xiv, 302.

smaller than the other, and in its centre. In the annular space left between the two, the various gradations of color, from blue to pink, are arranged radially, which being accomplished and the degrees of moisture marked, a piece of the prepared paper is placed in the inner circle, and the changes which occur can be thus conveniently read.

Sodium as an Explosive Agent.*—A contemporary calls attention to the fact that experiments upon the application of sodium as an explosive, which were originated, we believe, some years ago by Prof. Wurtz, of New York, are about to be recommenced.

In this connection it may be interesting to describe briefly the *modus operandi* followed in these earlier experiments. The theory of the plan here proposed, rests upon the great expansive force which will be exercised upon the walls of a vessel in a confined space, this force being readily called into operation by the hydrogen suddenly evolved in the decomposition of water by the sodium.

The device by which this may be utilized in practice, is described as consisting of two glass bulbs which are blown with a neck between them. One bulb is filled with sodium, the other with water—while in the neck connecting them a soluble salt is previously fused. The time required to fire the charge can be regulated at pleasure by the varying size or length of the neck. With this arrangement the apparatus is lowered into the drill hole, the sodium being below. The salt is gradually dissolved by the water and as this comes into contact with the sodium the explosion ensues.

In order to utilize the theoretical value of the charge it would be necessary that all the sodium should be expended in the decomposition of the water. How far this is accomplished in the arrangement just described, it is impossible to state with any certainty. But though it may be found to operate with good effect, it is clear that but a fraction of the possible power can be thus obtained, as the explosion will ensue before the sodium is completely utilized. The principle is, however, ingenious, and with such improvements in its application which a few practical trials will readily suggest, may prove in time a valuable addition to the art of blasting.

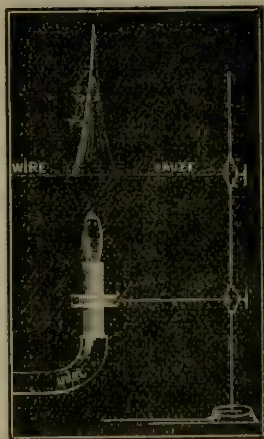
The Manufacture of Platinum.—In relation to this subject in one of the former issues of the Journal, the erroneous statement was made that there was but one establishment in the country for the manufacture and working of platinum. The statement, we have

* Journ. App. Chem., Dec., 1871.

since learned, is incorrect, and we now gladly add to the notice of the establishment formerly referred to, that of Mr. Joachim Bishop, of Chester County, in this State, whose announcement will be found amongst our business notices. We are informed that Mr. B. was for a long time the assistant of Dr. Hare, of this city, and that he has, for years, been making good use of the Doctor's discovery of the oxy-hydrogen blow-pipe.

New Form of Sensitive Flame.—Mr. Phillip Barry has sent a description of the accompanying new form of sensitive flame to Prof. Tyndall*.

The plan adopted consists in igniting the gas (ordinary coal gas) not at the burner, but some inches above it, by interposing between the burner and the flame a piece of wire-gauze.



The accompanying figure represents the arrangement. The space between the flame and burner being about two inches, the wire-gauze (composed of thirty-two meshes to the lineal inch) resting on the ring of the retort-stand, and being about seven inches square.

The flame is described to be a slender cone about four inches high, with the upper portion luminous and the base a blue flame. It is asserted to be the most sensitive of all sensitive flames, roaring at the least noise and sinking down to the surface of the gauze, becoming at the same time almost invisible. Being very active in its responses and rather noisy, its sympathy is apparent to the ear as well as the eye.

Manufacture of Hydrogen.—H. Giffard† has constructed an apparatus, the details of which are not specified, for the manufacture of hydrogen gas. At the works of M. Flaud, in Paris, where it was tested, the gas was obtained at the rate of about 70 cubic feet per minute.

The inventor passes steam over red hot iron, which, when nearly exhausted by oxidation, is reduced again to the metallic state by the action of a current of dry carbonic oxide gas.

* Nature, v, 106.
† Les Mondes, Oct. 13th, 1871.

A plan of this kind is perfectly rational, but to be worked with economy, it is necessary that the carbonic oxide used to revivify the exhausted iron should be generated at a lower cost than that of fresh iron. How it is produced in this case we are left to guess. It is more than probable, however, that a slow current of air is allowed to pass over an extended surface of glowing coals.

Experiments in the Mont Cenis Tunnel.—The Mont Cenis tunnel will perhaps be found of service in more ways than the one for which it is designed. Recent exchanges inform us that several *savants*, Pater Secchi amongst the number, are preparing to make it the scene of a number of physical investigations, which will include gravity measurements with the pendulum, observations upon magnetism and on temperature of the rocks. These experiments will be made in the tunnel itself, as well as upon the mountain through which it is bored.

It has already been ascertained that the passage of trains will not sensibly vitiate the accuracy of the proposed observations.

A Paraffin with a high Melting Point.—John Galletly* announces that he has obtained a paraffin having a melting point at 80° C. (176° Fahr.). The product was obtained in an impure residue from the manufacture of paraffin from Boghead coal. Its properties are thus described. It resembles beeswax in appearance, though more translucent and without the conchoidal fracture of this substance. It is crystalline; its melting point is as above stated, and it boils at a point but little below red heat, thereby undergoing partial decomposition. A candle made of this high melting paraffin burns with a clear smokeless flame, and lasts a long time. The new product may in time become of importance in the arts.

New Method of Observing Absorption Spectra.—E. Sommel† suggests the use of gelatin sheets in place of glass vessels in observing the absorption spectra of soluble coloring matters. The gelatin sheets are simply colored with the different substances, and permanently attached between two colorless glass plates. In this way quite a collection of different coloring matters may be made, which we are informed are quite durable. The alteration of the absorpsion spectra from the varying intensity of the solution, can be shown by imposing a number of the colored sheets upon each other. The

* Chem. News, xxiv, 187

† Pogg. Annalen, clxiii, 656

method is a simple one, and certainly far more convenient than that ordinarily used.

Railway Dust.—Mr. Jas. Sidebotham* has published a communication upon the composition of railway dust; having collected a quantity of the material by spreading a newspaper near an open window in a railway carriage, and subsequently subjected it to a microscopical examination. A large proportion of the fragments were found to be iron. They were mostly long, thin and straight, the largest being about ·150 inch, and had much the appearance of old nails. Of the original quantity collected (57 grains) one-half of it (29 grains) were removable with the magnet, and consisted therefore of iron.

The other portion of the dust consisted largely of cinders, some bright angular fragments of glass or quartz, a few bits of yellow metal, opaque white and spherical bodies, a few bits of coal, etc. The character of its constituents affords a satisfactory explanation for the irritating effects on the throat produced after inhaling the material.

Estimation of Graphite.—F. Stolba† communicates the fact that it is possible to determine, accurately enough for practical purposes, the percentage of carbon in commercial graphite by simple combustion in the air. He employs for this purpose a simple Bunsen burner, and announces that the burning of a few grammes of graphite is by no means so difficult as is generally supposed. The author places a weighed portion of the finely powdered and dried material in a platinum crucible, having a punctured cover. The crucible is placed over the flame in an inclined position, and the cover is placed so as to leave one-fourth of the same open. By this arrangement, by which a good draft is secured within and occasional stirring of the material, a few hours completes the operation, leaving the ash in an excellent condition for further analysis.

A Source of Error in Spectroscopy.—M. Blaserna‡ has made an interesting observation upon the influence which the temperature of the prism exercises upon the position of the lines. It has already been noticed by Verdet that where liquids are used for prisms the displacement of the lines is quite noticeable, the index of refraction altering with the temperature.

* Proc. Lit. and Phil. Soc., Manchester.
† Dingler's Journal, cxcviii, 213.
‡ Pogg. Ann., cxliii, 655.

For solid prisms, however, it was assumed that the influence of temperature changes upon their refractive power was quite insignificant. The author has found, however, upon observation, that this is not so unimportant as is generally believed; but that, while much less sensitive than liquid prisms, the displacement of lines could readily be observed with one of flint glass. The prism used in the experiment was one of Duboscq's, and was exposed for some time to the direct rays of the sun. It was then quickly placed in a spectroscope in the shade, and some prominent line observed, when it was found that as the glass cooled the refractive power increased. (An opposite result is obtained for bisulphide of carbon.) He was enabled to observe in this manner a displacement of the D line amounting to 3″ for a difference in temperature, equal to 1° Cent. In the instrument used the interval between D and D′ is 12″, so that a change of 4° C. would suffice to place D in the position of D′. The author remarks, as the result of his interesting observation, that an error might very readily be made in spectroscopic work by comparing together observations made in sunlight and in shade, or those made in the morning with those in the night.

Passivity of Cadmium.—Dr. Schönn announces that the metal cadmium may, under certain circumstances, be rendered indifferent to the action of acids. It has long been known that iron, if plunged into this acid of a certain degree of concentration, acquires a peculiar surface condition, rendering it indifferent to the action of the strongest acid. Iron which has undergone this surface change has been termed passive. It appears, too, that such iron has acquired some peculiar physical qualities, since it will form a galvanic circuit with ordinary iron; the changed metal behaving electrically negative to the other. That such iron has really been decidedly altered in character is evinced again by the fact that it refuses to reduce copper from solutions of its salts.

It appears, from Dr. Schönn's observation, that if cadmium is wrapped with some platinum wire, it may be placed, without being in the least acted upon, in strong nitric acid; though if the wire surrounding is removed, or if the acid is diluted, the cadmium is instantly attacked, thus showing that the passivity of the cadmium is due entirely to its contact with the platinum. The same author has shown that tin will give the same phenomenon.

Action of Light on Cane Sugar Solutions.—M. Raoult* communicates the fact that a solution of cane-sugar may be converted into grape sugar (glucose) under the influence of light. The observation was made in the following manner:

A concentrated aqueous solution of cane sugar was placed in glass tubes, which were sealed while their contents were boiling. These were placed near each other, under the same conditions, with the sole difference that one was kept in total darkness, while the other was exposed to the bright daylight. Several months later the tubes were examined, when both solutions were found, under the microscope, to be free from vegetable matter. The solution, however, which had been in the light, at once gave an abundant red precipitate with a copper salt on addition of a free alkali (the test for grape sugar); while the contents of the tube kept in the dark, gave no sign of the reaction.

A new Reagent for Copper.—Mr. Hugo Tamm announces that a mixture of the sulpho-cyanide of ammonium and bi-sulphite of ammonia in equal parts, which will keep for several months in aqueous solution without decomposition, is an admirable reagent for copper. It is volatile, and can therefore be driven off completely on evaporation to dryness, it forms a very insoluble pulverant precipitate, a white sub-sulpho-cyanide, which can readily be washed, and it affects scarcely any other metal which may happen to be present.

The Source of Nerve Force.†—Mr. J. St. Clair Gray is the author of a view concerning the origin of nerve force, which he is very judiciously endeavoring to verify by actual experiment. The author, starting from the assumption that this power had in it an electrical element, arrived finally at the conclusion that its source is to be sought for in the sulphur and phosphorus in the animal system.

It is well known that phosphorus exists in considerable quantity in the brain, and that sulphur is present in the liver, while an alkaline fluid is in constant circulation between them.

To determine the fact as to whether a combination of similar elements would generate an electric current, he constructed a cell containing caustic potassa, in which were placed sticks of sulphur and phosphorus. Chemical action very soon set in. The phosphorus was soon converted into an oily mass, the sulphur gradually wasted away

* Comptes Rendus, Oct. 30th, 1871.

† English Mechanic, xiv, 317.

at the point of contact with the former, while potassa salts were formed in the solution. The operation was attended with the evolution of phosphuretted and sulphuretted hydrogens.

The action seems to be very gradual, since we are informed that at the end of three months it was still going on. The presence of an electric current in the cell was conclusively established by the electrometer, the electro-motive force of the current being found to be superior to that of the Daniell cell.

Having thus established one fact in favor of his hypothesis, the author next proceeded to test its truth under the actual conditions of life. The leg of a frog was prepared as a galvanoscope according to Galvani's directions. A rabbit was then chloroformed, and through an incision in the abdomen an insulated copper wire was introduced into the substance of the liver, and another similar wire passed through the optic foramen into the brain. The free ends of the wires were then brought into contact with the exposed nerve of the frog's leg, when powerful convulsions were produced in it; a very clear demonstration that an electric current does exist between the brain and the liver. From these facts the author infers that the source of the current is the action of the alkaline fluid on the sulphur and phosphorus in these organs; especially since he has shown, from his experiment with the cell constructed on this principle, that the combination of these elements is capable of generating a very powerful current.

The experiments are still being continued, and we shall doubtless soon be informed either that subsequent investigation has disproven this ingenious theory, or that the source of nerve-force is discovered. The very obvious objection that sulphur and phosphorus do not exist *as such* but as compounds, in the liver and brain, must, of course, be considered as militating against the author's views, until it is shown to the contrary.

Editorial Correspondence.

Brick-dust Cement.

PHILADELPHIA, Dec. 20th, 1871.

To the Editor of the Journal of the Franklin Institute.

DEAR SIR—It may not be generally known among builders in this country, or to the majority of your readers, that in the Spanish do-

minions ordinary brick-dust, made from hard burned, finely pulverized bricks, and mixed with common lime and sand, is universally and successfully employed as a substitute for hydraulic cement.

The writer, during an engineering experience of six (6) years in Cuba, had ample opportunity for testing its merits, and found it in all respects superior to the best Rosendale hydraulic cement for culverts, drains, tanks or cisterns and even for roofs ; whether for setting flat tiles, or for making the usual tropical concrete flat roof.

It is regularly known there as an article of commerce, sold in barrels by all dealers in such articles at the same price as cement. The proportions used in general practice are one of brick dust and one of lime to two of sand, mixed together, dry and tempered with water in the usual way. A greater or less quantity of the brick dust is sometimes employed when considered desirable. The writer cannot say whether this composition has ever been tried in this country, or whether it would retain its virtues when subjected to the action of frost.

It would seem, however, that it could be produced at a lower rate than cement, by the addition of pulverizing mills to our brick yards to utilize the waste and broken bricks ; and if found successful, its manufacture might be worth considering by those who are interested in such products.

Very truly yours,

F. B. Miles.

Note.—Under the paragraph headed Hydraulic Cements in Trautwine's Engineers Pocket-book (recently published) mention is made of the same material ; from which it appears that it is considerably used in France. The author of the work in question pronounces it, from his own observation, to be decidedly hydraulic—a block of the same one-half inch in thickness, without sand, after immersion in water for four months, bore, without crumbling, crushing or splitting, a pressure of 1500 lbs. per square inch. The opinion is further expressed that the addition of even as little as one-tenth as much brick dust as sand to our ordinary mortars, would prevent the disintegration so generally visible in the mortars used in masonry.—Ed.

Civil and Mechanical Engineering.

PATENT INVENTION.

By J. Richards, M. E.

When any public interest becomes the subject of controversy, when widely different opinions are drawn from apparently the same premises, it is generally safe to assume that there is some inherent error that lies at the bottom—some principle that is at variance with the laws of political economy, or of science, as the case may be. With this proposition I beg briefly to consider the subject of patent inventions, in view of the present agitation of the matter in England and the United States.

Our courts have for two centuries puzzled their brains to define what constitutes invention—where devices or combinations end, and where principles begin; to define what principle means, as applied to machines, &c., &c.

Our legislators have grappled this knotty subject of property in invention (as is plainly their duty); long harangues are the result. A commission costing thousands of pounds has, in England, been set at work to unravel this troubled question of patents.

The history of the Netherlands, with their mechanical achievements of two centuries ago, are dragged into the argument; men skilled in procuring patents are placed at the bar to give testimony as to the patent system. (The writer must, however, be careful in reviewing this matter, as he has not mustered the courage to go through the proceedings of the commission.)

Now, Mr. Judge or Legislator, is it not possible that there is something behind all this trouble about patents that has been lost sight of, and are you not trying to frame *civil* laws to govern that which belongs to the field of *science?* Has not the demonstration of the mechanical equivalent of heat, the laws of forces, laws of construction, &c., under the rapid advances of the few last years, "underminded" your old theories about property in invention?

Assuming the proposition given at the outset to be true, the writer as an engineer and patentee of numerous inventions, begs to submit the following views in regard to patents, which, so far as he knows, have not been embodied in any of the very able discussions heretofore had on this subject, trusting that, whether true or erroneous, they

will contribute something to the settlement of a question in which he feels a great interest.

To present his views in a manner intelligible to all, the following propositions are submitted:

First. Invention, in accordance with the general acceptation of the term, means "discovery," a finding out of something not known before, not by consecutive deductions from certain known premises, but a kind of "accidental" discovery. It might also be said to mean a kind of "intuition" that reveals what is sought through a faculty called genius.

Second. Demonstration by deductions from known premises or data, wrought out by mathematical or engineering knowledge, is not invention in the sense above, nor can it be comprehended in the intent of the law relating to discoveries or inventions.

Third. The necessity for, or even the very existence of such a thing as invention or discovery, in the popular sense, is found wholly in our imperfect knowledge of scientific law, and the age in which it was found to be expedient or necessary to offer *bribes* for such discovery has passed away.

In reference to the first proposition, it is hardly worth while to offer anything in its support, that inventions means in a popular way a kind of "chance finding out" none will dispute. It has ever been regarded as a kind of supernatural gift. Inventions have had thrown around them the cloak of secrecy, and the public mind has always been educated to a kind of mystery in regard to patents.

Think of a State offering premiums to its subjects for the discovery (not demonstration) of a "perpetual motion," whatever that may be. Think of the thousands of pounds and the hundreds of useless lives that have been sacrificed on this altar of mechanical discovery, and we must go far back to the dark ages of alchemy and superstition to find a parallel.

The second proposition, as to what does not constitute invention, is more important. In its support no stronger argument can be adduced, nor even wanted, than the trouble that has ever existed to define what constitutes invention, such invention as could by right become the property of the individual. It has been held that such invention must not comprehend a principle; next, a principle must be defined, which we are told is a "mode of operation," and that the devices may be claimed but not their "manner of operating;" but then these devices we claim are, of necessity, mechanical agents, gen-

erally known both to practice and philosophy. Yes, true, but there is the combination of these elements that is proper subject-matter for a patent and exclusive right. Grant that, but it is further held that at least one element in a particular combination must be new; "new" in what sense? there is rarely a new mechanical movement discovered; new in the sense of not being known to the laws of physics, and there can be no new element among mechanical devices in these combinations.

We are also told that a combination of old elements to produce a new result is proper subject-matter for a patent, which, like the former assumption, if followed out ends at the same point, just where it began, and has no meaning that is sufficiently tangible for the mind to grasp. The inevitable conclusion is, there is *nothing* in invention which can of right become the property of the individual, for the want of our power to define it. If there is anything to which he has a natural right it could certainly be so defined as to come within the scope of ordinary comprehension.

Results attained, then, by deductive reasoning are not inventions—not discoveries at least in the accepted sense, for two persons with similar premises will attain like results in pursuit of a given object; the premises—laws—data—or whatever else we may term them, are open to all. The scientific or practical attainments of the inventor are but borrowed from popular sources, and the experience and knowledge of others, hence results or demonstrations, inventions if you please, thus wrought out cannot of right become the property of the individual, and cannot certainly be the intent and meaning of the statute relating to invention.

The third proposition is a bold one, no doubt, but nevertheless true in the abstract, so far as relating to mechanical invention, at least: every invention or discovery in mechanics must, of necessity, be found to conform to the laws of science. The difference, then, between what we will term "legitimate" and "illegitimate" invention, is that in the one case the result is discovered by tracing it out through the medium of these laws, as from cause to effect; in the other by groping about until, by chance, we light upon the result, and then by a negative course *follow back* these laws to prove its conformity with physical science; to make a plain illustration, it is like making a search for the missing end of a thread, in one case groping about to find it by accidental discovery, in the other by following the thread itself to the missing end.

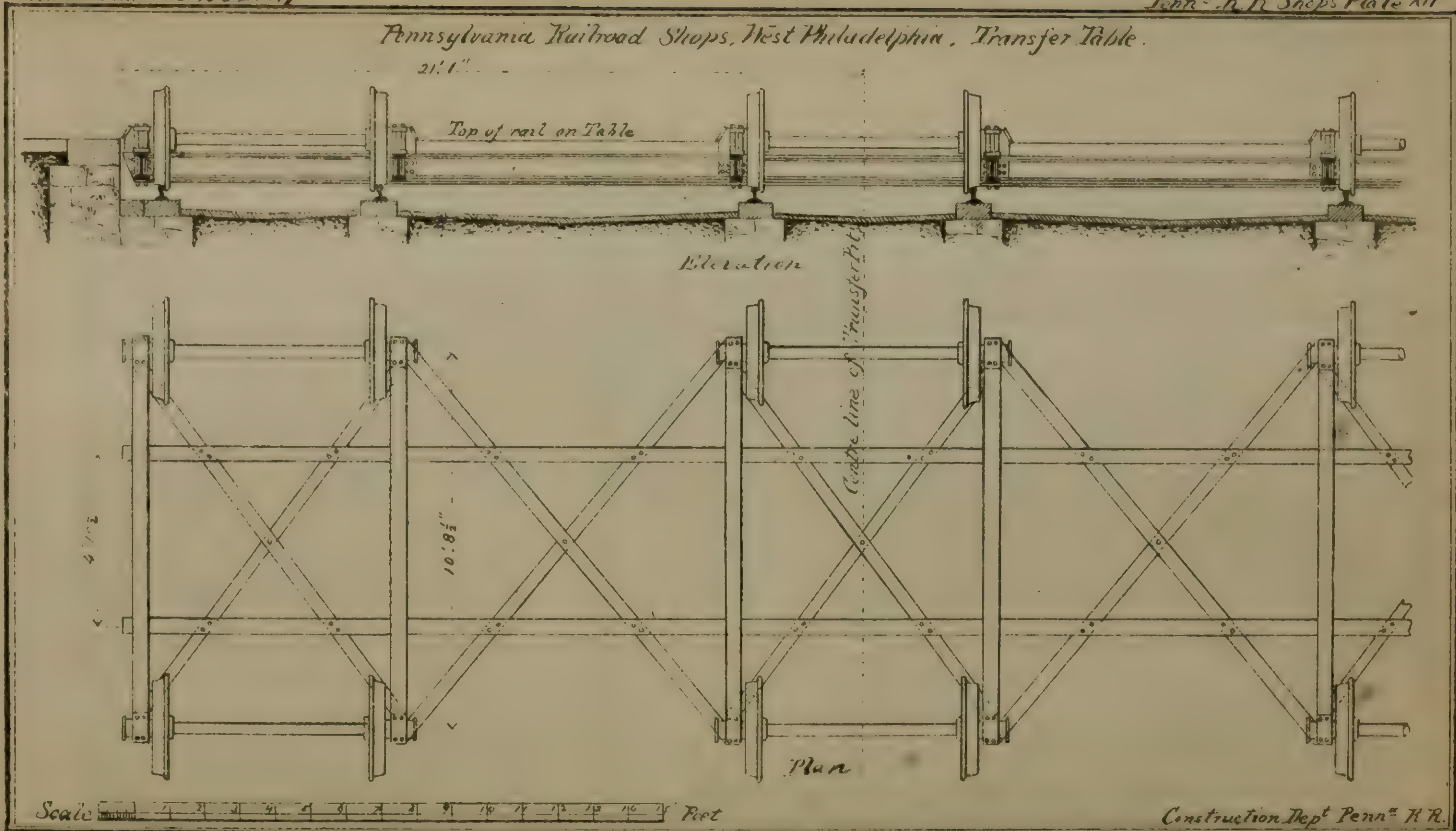
To show by a more familiar example that this proposition is not a chimerical one, let us suppose that an existing fault or want has been demonstrated. This fault or want we will suppose, for example, to be the tendency of railway trains to overturn in making sharp curves. Let us next suppose two inventors, one of the illegitimate school, setting about to "discover" a remedy, without scientific knowledge, but with the incentive of "personal right" in his discovery when made; the other, an engineer educated in the laws of physical science and construction, moving in the legitimate performance of his professional duty.

The first commences by tasking what is termed his "ingenuity" for expedients to keep the carriages on the track. Mechanical devices of various kinds present themselves to his mind; he thinks of gib hooks beneath the rail; he thinks of a shifting load to move to the short side of the curve, of a wider wheel base, of greater weight to keep the carriages down, of lowering the weight to get it between the rails; finally he hits upon an expedient which is *tried;* it fails, is modified, *tried again*, is abandoned for another, until, after expensive experiments, the true remedy may or may not be reached.

On the other hand, let us suppose the same matter to be taken in hand by the legitimate inventor, or "demonstrator" is the better term. He begins by ascertaining the conditions, finds a force acting which tends to overturn the train, a force with which he is familiar, as the tendency of moving bodies to remain in one plane, the extent, direction and influence of this force is all measured by laws which he knows to be fixed and constant.

The train being in motion, no stationary resistance can be opposed to this force, neither can it be destroyed nor its course changed; hence his teachings tell him it must be met and neutralized by a force acting in an opposite direction; this cannot be had, but acting at right angles is the force of gravity, which can be used; it is already acting, but insufficient in degree. To increase it he raises the outer rail until the centre of gravity has reached a position to balance the centrifugal force of the train, and has accomplished, without experiment, without discovery, all that can in the nature of things be possible to remedy the fault, and yet done nothing outside the regular exercise of his professional duties, certainly nothing to give him the right of property in the result.

It might be safely asserted that the loss of time and loss by experiment, to say nothing of the influence to retard legitimate engin-


Pennsylvania Railroad Shops, West Philadelphia, Transfer Table.
21' 1"
Top of rail on Table
Elevation
Centre line of Transfer Pit
10' 8½"
Plan
Scale
Feet
Construction Dept. Penna. R. R.

eering, has, by this system of *bribes for discovery*, done more harm than good for ten years past.

It might also be assumed that we have now reached a period when the rights of the people, the dignity of legitimate engineering and public interest demands its discontinuance.

The impossibility of the proper administration of a system founded in error, is of itself no doubt a sufficient reason for its discontinuance, but we can now afford to place it upon higher grounds.

In conclusion, the writer desires to say that nothing is further from his intention than to cast any reflection upon the many highly important inventions that have come to us through the school of "discovery," nor is it the intent to declaim against a system that has had its place in the development of our arts, but simply to claim that its faults have not been traced to the proper source and that its time has passed away.

We no longer need the incentive of personal right in invention or demonstration to develop our arts, and the writer, from his own observation, both in England and America, finds that the better class of engineers and mechanicians have come already to look with disfavor upon patents, a question of fact which will be confirmed by as many as have noticed the matter, and one that can be determined by searching the records of the patent office for the names of our best engineers.

PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.

P. A. Engineer Construction Department Pennsylvania Railroad

(Continued from Vol LXII. page 320.)

Transfer Pit and Table. The transfer pit is located between the locomotive shop and the passenger car shop, so that it may be used for shifting both locomotives and cars. It is 244 feet long and 42 feet 2 inches wide, inside dimensions. The side walls are of stone 2 feet thick, with a cut stone coping course on top, 18 inches wide and 9 inches deep, the rails of the tracks from the shops being cut into this coping, so that the top of coping is flush with top surface of rails. There are three tracks on the floor of the pit running in the direction of its length, to guide the movement of the transfer table. Each rail is laid upon a 6 by 12 inch white oak track stringer, having a foundation wall under it 20 inches thick, the track stringer being firmly fixed to the foundation by anchor bolts at frequent in-

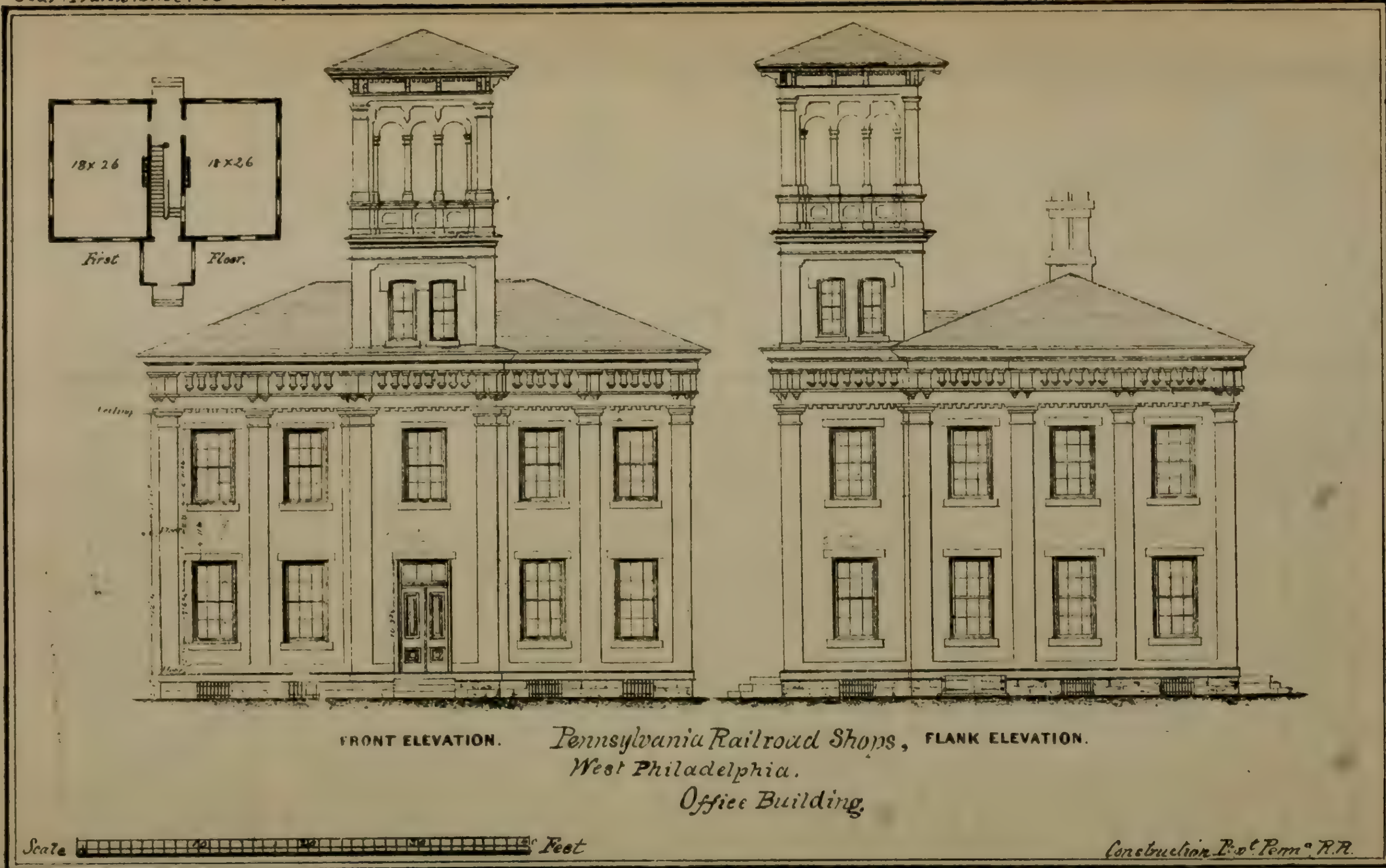
tervals in its length. The floor of the pit is paved with brick laid flat in sand, the proper grades being given to the different parts, so that surface water may drain off into sewer openings provided for the purpose at three points in the length of the pit.

The transfer table, designed and manufactured by Williams Sellers & Co., of Philadelphia, is constructed entirely of wrought-iron, except the wheels, which are the usual cast-iron wheels used on American roads. Plate XII gives a plan and elevation of this table. The table proper, which is suspended from six pairs of wheels, is built of rolled heavy 9 inch I beams, weighing 150 lbs. to the yard. There are six cross-beams suspended from the wheel axles, and two longitudinal beams, one under each rail of the track on the table. The top flanges of these beams are in the same plane, and where the beams meet, those running longitudinally are cut and connected to the others by splicing plates and rivets. Diagonal plates, 1 inch by 4 inches pass underneath, being riveted to the flanges of the beams wherever they pass them, thus thoroughly stiffening the structure laterally. The rails on table are laid directly on to the longitudinal I beams and bolted fast. The height from base of rail on table to base of rail on floor of pit is 14¾ inches. The length of table is 42 feet, an allowance of one inch being made at each end, less than the width of the pit, for clearance.

Office Building. The office building, situated as marked No. 8 on general plan, is a two story structure of brick, with a bell tower, the plan and elevations being given on plate XIII. The first floor plan is arranged with a hall through the centre and a room on each side, one being the master mechanic's office and the other a clerk's office. From the clerk's office a reporting window opens on to the hall, and all the mechanics in the establishment, before going to work, pass through this hall and report their presence to the proper clerk, situated at this window.

The second story is arranged on the same plan as the first, the rooms being used as offices by the car department.

The bell in the tower is of cast steel, 37 inches in diameter (note B) and weighing 836 lbs. It was manufactured by Vickers Sons & Co., limited, Sheffield, England. It is claimed for bells of this material, that they have a very pure, rich and melodious tone, and their sound penetrates to a greater distance than that of any other kind of bell; that they are stronger and more durable than any other, having stood



Pennsylvania Railroad Shops, West Philadelphia. Office Building.

the severest frosts without injury, and that for the same diameter and depth of tone they are of less weight than if made of bronze or composition and at the same time of less cost per pound. These bells are in use at four different points on the line of the road, and have, so far, been very satisfactory.

(To be continued.)

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from Vol. LXII. page 404).

The machine, fig. 1, is a direct acting cutting engine for the manufacture of thin boards for bandboxes, or other uses of a similar nature.

The reciprocating carriage shown on the top of the main frame, has a throat similar to an ordinary plane, with an adjustable cutter projecting from its upper face to suit the depth or thickness of the boards to be cut, the face being, of course, adjustable, so that the extreme projection of the edge will be in the plane of table or platen behind the cut. This carriage has a reciprocating motion by means of the winding cord seen in the engraving, which moves it steadily forward, and then allows a quick return for the succeeding stroke.

The block from which the pieces are to be cut is seen on the top of the carriage, where it is held against the face of the knife by means of the abutting brackets, and is forced down by means of the weighted lever shown.

To keep this lever in a horizontal position, as the wood recedes, the fulcrum is so arranged as to move down with the block, actuated by the machine itself.

The speed for ordinary cutting is ten revolutions per minute; weight two and one half tons.

The machine, fig. 2, operates much on the same principle as the one shown in fig. 1. The wood, however, in addition to being cut off in thin boards, is also divided into match splints, at the rate of ten thousand per minute when the whole capacity is employed, or, in other words, when the feeding box is full. The wood blocks are put into the hopper or box seen on top, and, projecting through the bottom, come in contact with the plane or cutter frame, which has a reciprocating motion by means of the crank shaft as shown.

A cut being made and the cutter frame drawn back, the block drops to the extent it has been cut away, ready for the next cut.

The scale is one-twenty-fourths, weight sixteen hundred pounds, speed two hundred revolutions per minute.

Fig. 3 is a true side elevation of a jointing machine for box boards or other short stuff, intended, however, for glue joints of all kinds. To form glue joints by machinery that would be as perfect as those made by hand has been the object of many machines that have failed to accomplish the purpose. The plan here employed, of fastening a number of pieces in an iron carriage moving on strong guides, is no doubt the best that can be adopted to secure true joints.

The lumber, as shown, is set into an iron frame clamped by means of the hand wheel in the front, the lower edge projecting down to meet the cutter shaft; this carriage is traversed by means of the screw and bevel gearing, which can be readily understood from the drawing.

ON THE FLOW OF WATER IN RIVERS AND CANALS.

By J. Farrand Henry, Ph. B.

(Continued from Vol. LXII. page 389.)

Bottom Velocity.

Capt. Boileau says:* "The observations should be continued to a short distance from the bottom, for in that region the velocities decrease rapidly." And again:† "Returning to the observations made by Dubuat upon the movement by translation of grains of sand which follow the bottom of the canal, let us compare these movements with that of the liquid at the same depths. According to that engineer's estimates, the velocity of translation was only about 0·003 of an inch (0·00008 m.) per second in a current where the lower layer of water moved at about one foot (0·325 m. per second, a result which at first appears inexplicable; for, even admitting a notable error in the measurement, these quantities still differ enormously. However, remarking, in the first place, that Dubuat measured the bottom velocities in his experimental canal, by means of small spheres 0·24 inch (0·006 m.) or less in diameter, while the grains of sand were not over one-tenth this size, it seems that the molecules of liquid very near the bottom have a very slight movement, and that in the small inferior zone or layer the velocities increase very rapidly to a certain height, where this increase follows the laws discovered by means of the hydrometrical instruments.

* Mesure des eaux courantes, page 302. † Idem, page 339.

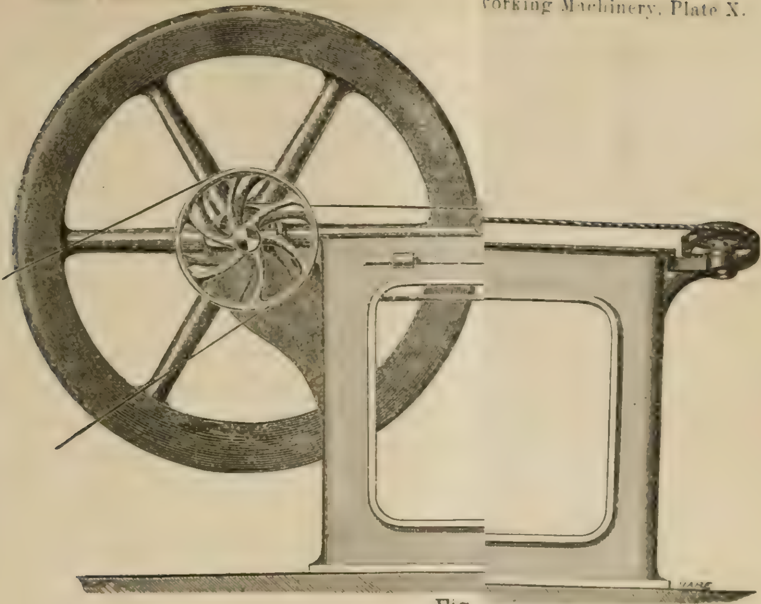


Fig.

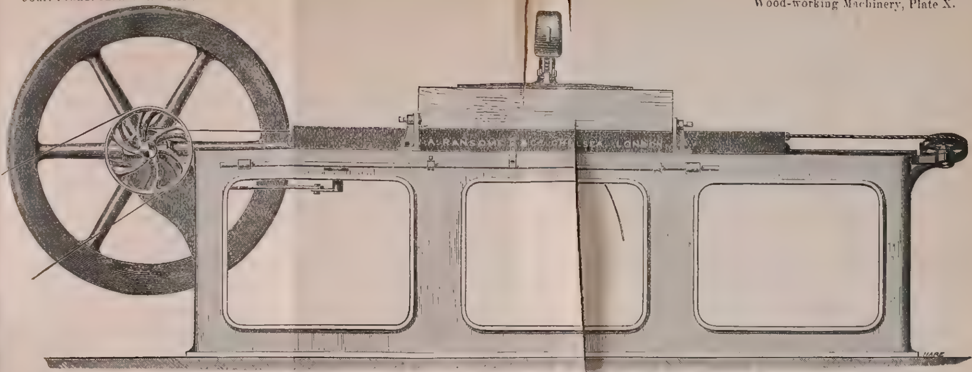


Fig. 1.—Scale-board Machine. Allen Ransome & Co., Engineers, London.

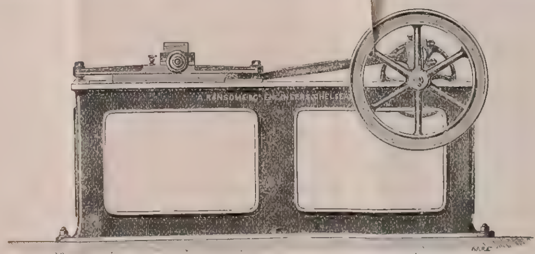


Fig. 2.—Match Machine. A. Ransome & Co., Engineers, London.

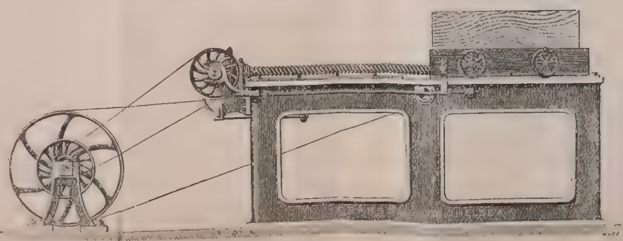


Fig. 3.

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Fig 6

Difference of Floats & Meter

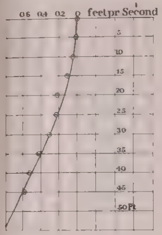


Fig 8

Surface & bottom Velocity Curve, NIAGARA RIV.

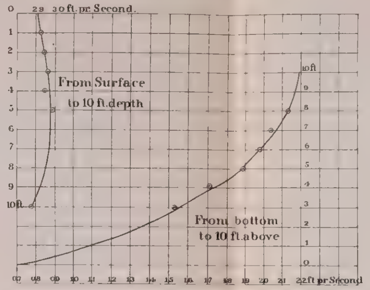


Fig. 10.

Vertical Velocity Curves NIAGARA RIV.

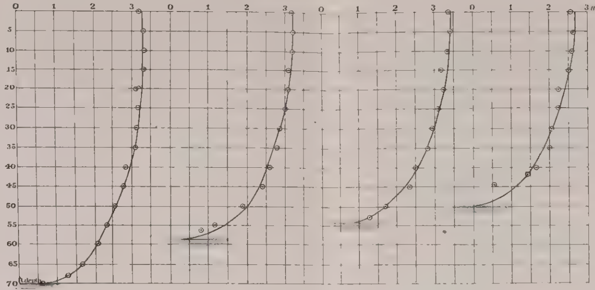


Fig 12

Horizontal Velocity Curves in S^t. Clair River

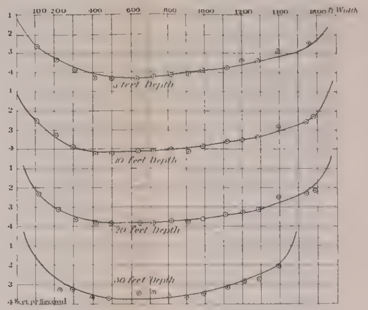


Fig 13

Capt BOILEAU'S observations in small Canal at Metz

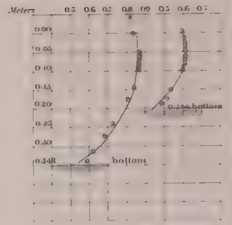


Fig. 7.

Surface & bottom Velocity Curves S^t. Clair River.

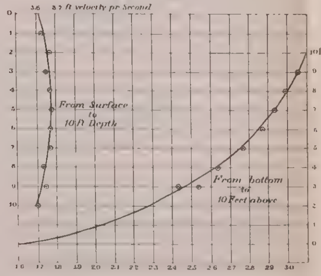


Fig. 9

Vertical Velocity Curves in St. Clair Riv.

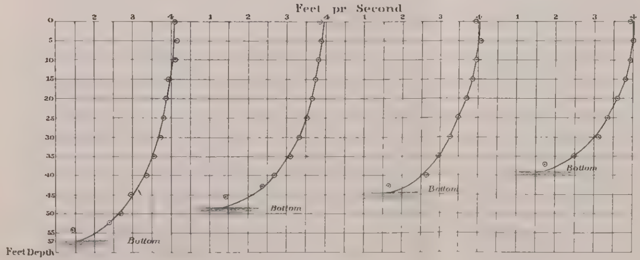


Fig. 11

Vertical Velocity Curves St. Lawrence

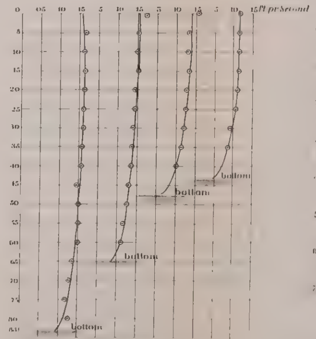
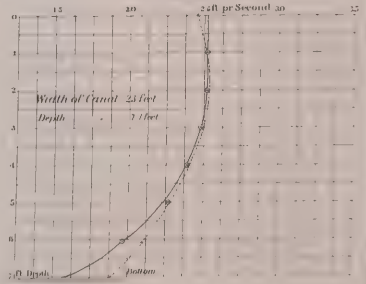


Fig 14

Vertical Velocity Curve of Feeder of O & C. Canal obtained by Floats HUMPHREY & ABBOT



"This circumstance seems to confirm the opinion of Dubuat and the greater part of hydraulic engineers, who hold that the fluid molecules in immediate contact with the bottom of the canals are made immovable by their adherence." Then follow his remarks (already quoted*) on the formation of eddies.

To obtain actual measurements of the bottom velocity seems almost impossible.

In small canals the distance between the lowest measurement and the bottom affords ample space for great changes in the velocity, as Dubuat's experiments show; and in deep rivers it is difficult to get a meter close to the bottom, or rather to know exactly how near the bottom it is; and, as the pulsations of the current are so great in that region, the velocity will sometimes be so slow that the meter will stop for a time, and thus make the mean too large. Floats, as we have seen, are entirely unreliable for such observations, for the exact depth of the lower float can never be known, and they invariably give too high velocities.

Notwithstanding the experiments noted above, Dubuat gives a formula for the bottom velocity which makes it a little more than half that at the surface. He considered also that the bottom velocity was the same for like surface velocities, whatever the depth of the stream, and that it was not affected by the nature of the bed.

Darcy and Bazin have shown that the nature of the bed materially affects the velocity, a different constant being used in their formula for beds of plank, masonry, cement, earth, &c., and the later observations seem to show that the bottom velocity changes with the depth also.

The bottom velocities given by Dubuat's and other formulæ, and found in all hydraulic tables, can only be considered as the lowest measured velocity. Dubuat, Blackwell and others have measured the velocity of currents capable of moving different substances, which may be condensed as follows:

16	feet	a minute	will start white clay.		
40	"	"	"	move along coarse sand.	
60	"	"	"	"	fine gravel.
120	"	"	"	"	rounded pebbles 1 inch in diameter.
200	"	"	"	"	flint stones size of hens' eggs.

Beardman's tables, which are computed by Dubuat's formula, give a bottom velocity of 2·92 feet per second for a surface velocity of four feet per second, or about three miles an hour. This, according

*Ante, page.

to the above table, would move along pebbles over an inch in diameter; while we know from experience that rivers of a much greater surface velocity run over beds composed of soft sand or finely comminuted clay, with but little change in their cross section, through quite long periods of time. In a small clear stream, I have watched the gathering of small particles of vegetable or earthy matter, whose specific gravity was so nearly that of the water that they would just sink upon the small stones at the bottom, but if they were disturbed so as to rise out of the lower layers of water, they would be immediately carried off by the current.

At times, of course, when the conditions are favorable, the scouring of rivers is very great, but ordinarily they appear to have but little action on the bed.

In the report of Mr. Chas. Ellet, Jr., on the "Inundations of the Mississippi," is the following:* "To excavate a channel through soil of a given texture, and to keep the same channel open when so excavated, are two very distinct things, requiring very different applications of force. We find, consequently, that it is no easy thing, even with a great fall and a great volume, to open a new channel by the mere action of the running water of the Mississippi. The first attempt to make a cut off at Racourci, where the fall was at the rate of six feet to the mile, were unsuccessful, although a considerable volume of water was let through an artificial trench leading from the river above to the river below the bend. Various other attempts to create cut-offs across bends in the upper portions of the river have likewise been unsuccessful, although sometimes aided by a descent of 7 or 8 feet per mile.

"The Atchafalaya and the Plaquemine have probably been open for ages—certainly from periods far beyond the reach of history or tradition—the first having a fall more than twice as great, and the other a fall *ten times as great* as the Mississippi itself; and yet, unaided by art, they have been found unequal to the task of increasing the depth of their channels, or enlarging their respective waterways. On the contrary, the Atchafalaya, in the view of the writer, seems to have been contracting its original width for a great many years.

"The crevasse at Bonnet Carré discharged into Lake Ponchartrain about the one-tenth part of the high-water burden of the Mississippi, for many consecutive days, during the great flood of 1850, when the water of overflow rushed down a plane descending about fifteen feet

* Ex. Doc., 20, 1852, page 67.

in $4\frac{1}{2}$ miles; and yet the velocity and force of the torrent were not sufficient to tear up the natural soil to any considerable extent. No channel was excavated. The furrows left by the plow and the roots of the crop remained on the field where it had been swept by the water, after the flood had subsided."

There were also two attempts to make artificial cut-offs during the Rebellion, which were unsuccessful.

A curious story was told by the divers employed in the construction of the St. Louis bridge across the Mississippi. It must be taken for what it is worth; yet it seems hardly possible that it could have been an invention of their own:

During the sinking of those piers, large scows were moored alongside; and the divers reported that the bottom of the river underneath the scows was scooped out just about the amount they extended beneath the surface. This would seem to show that while the river was in its normal condition—the discharge and cross section being in equilibrium—the sand and silt of the bottom was undisturbed; but an obstruction being placed in the stream which reduced the cross section, the velocity at the bottom was increased till the equilibrium was restored.

If an obstruction be placed in the bottom of a river, thus lessening the cross-section, the surface level will be raised; and if an obstruction be placed near the surface, it would seem as if the bottom or sides must yield.

These are, of course, only conjectures, but they all seem to indicate that the real bottom velocity in rivers must be very small.

In the Mississippi observations, the bottom velocity exceeds that of the surface in 28 out of the 69 selected verticals, in some cases being more than one foot a second in excess, and in one vertical, as has been already mentioned, the *maximum* velocity is recorded at one foot *below the bottom.*

It was found impossible to obtain satisfactory results in the rivers connecting the lakes below about three feet from the bottom, both from the uncertainty of position, and the intermittent velocity, as before noticed.

The means of the measurements from that depth to ten feet from the bottom are given in Table X, and are also plotted in figures 7 and 8, being represented by the circumscribed dots.

A free hand curve, shown by the full line, is drawn through as many of these points as possible, and continued till it meets the bottom; the ordinates of this curve being also given in the table:

TABLE X.

Distance from the Bottom.	St. Clair's River.		Niagara River.	
	Observed Velocities	Ordinates of Curve.	Observed Velocities.	Ordinates of Curve.
10	3·053			
9	2·988	0·060		0·040
8	2·935	0·115	2·124	0·095
7	2·870	0·180	2 034	0·175
6	2·782	0·250	1·975	0·260
5	2·734	0 330	1·889	0 360
4	2·624	0·440	1·710	0·495
3	2·437	0·590	1·536	0·660
2		0·790		0·870
1		1·050		1·120
Bottom...........		1·550		1·500
No. of Verticals	33		20	

These curves show a very rapid decrease in the velocity towards the bottom, and thus agree with Dubuat's experiments on the translation of grains of sand; but the bottom velocities are still very large compared with the slow motion of those particles, being nearly a foot and a half a second in the St. Clair and seven-tenths of a foot in the Niagara.

According to the table on page , the former velocity ought to carry along coarse gravel; yet, while the bed of the St. Clair is composed of clay so soft that a sounding lead sinks into it a foot or more, the form of the bed has not changed materially in the past ten years.

The mean surface velocities corresponding to these bottom velocities are, in the St. Clair, 3·6 feet per second, and 2·9 in the Niagara.

The depth of the former river is over fifty feet, and of the latter about 70 feet.

This shows, as far as a single case can, that the bottom velocity is dependent on the depth as well as on the surface velocity, and the character of the bed; which seems much more rational than that it should be a function of the surface velocity alone.

In an article in "Nature," by Mr. S. Login, upon the abrading and transporting power of water, the following "Practical Conclusions" are arrived at:

"1st. That all particles of water have an affinity to each other, as to other bodies, and that force is required to separate them.

"2d. That friction sets these particles rotating in all directions, in larger or smaller circles, and that the friction or force increases in some proportion to the area of surface exposed.

"3d. That this rolling motion becomes rarer the larger the diameter of the circles may be; that is, the resistance decreases as the depth and breadth of the stream increase; or, in other words, the velocity increases proportionally to the 'hydraulic mean depth.'

"4th. Lastly, that any increase to the rapidity of this rotatory motion must increase the abrading and transporting power of water, by enabling it to remove from the channel of a stream grains of solid matter, and hold them in suspension."

And he quotes from a series of papers in "The Artisan," the following "Supposed Law:"

"The abrading and transporting power of water increases in some proportion as the velocity increases, but decreases as the depth increases."

This idea of the rolling motion of water caused by friction is the same as that of Captain Boileau of the eddies, which he thought were generated by the adhesion of the water to the bottom of the stream; and if, as seems to be true, the resistance, and therefore the abrading power of water decreases as the depth increases, the bottom velocity must also decrease even should the surface velocity be the same.

Form of Velocity Curves.

Almost every writer on the subject of hydraulics adopts a new form of velocity curve.

Woltmann found that a reversed parabola, with its vertex below the bottom of the river, agreed best with his observations on the Rhine.

Defontaine, also on the Rhine, found the greatest velocity at the surface; that it decreased slowly at first, and then more rapidly towards the bottom, and he considered that this decrease approximated to two right lines of different inclinations, intersecting at a point probably below mid-depth.

Racourt, in his current measurements on the Neva, found the decrease in the vertical velocity was best expressed by an ellipse whose minor axis was a little below the surface. He also found that the same curve would agree closely with the increase of the velocities in a horizontal plane from the banks to the center of the stream.

Funk adopted a logarithmic curve in his observations on the Weser.

Boileau found a parabola, with its axis at the surface, agreed best with his observations on experimental canals.

Darcy and Bazin found the reversed parabola approximated most closely to the velocities they obtained, but the parameter changed with the character of the bed.

Humphreys and Abbot, in the Mississippi observations, adopted a parabola with its axis three-tenths of the depth below the surface.

M. Baumgarten says: "In constructing the curve of different velocities corresponding to each point of vertical height of a sounding, we can assure ourselves that the engineers who have maintained that the curves were ellipses, or right lines with a slight inclination to each other, might all have been more or less nearly right (pouvaient tous avoir plus ou moins raison), according to their observations; but I believe that in reality no simple curve gives a rigorous expression of the truth, and that they are all merely approximations, even as ellipses are but approximations to the orbits really described by the planets."*

In the survey for the outflow of the lakes the method adopted for obtaining the vertical curve of velocity was to combine all the observations or verticals whose depth did not differ more than three feet.

Four of these combined verticals for each of the rivers of St. Clair, Niagara and St. Lawrence are given in Table XI.

The velocities are a mean of all the observations at the places and depths noted.

In the St. Clair and Niagara the surface and bottom velocities are taken from the curves given in Tables IX and X.

As these curves are not applicable to the St. Lawrence river, those velocities are omitted.

TABLE XI.

ST. CLAIR RIVER.

Depth.	54·6 feet.	45·4 feet.	42·5 feet.	37·0 feet.
	4·034	3·868	3·958	3 409
5 ft.	4·109	3·907	4·013	3·484
10	4·043	3·821	3·900	3·379
15	3 958	3·709	3·798	3·223
20	3·887	3·608	3 663	3·050
25	3·778	3·496	3·501	2·784
30	3·624	3·309	3·228	2·529
35	3·503	3·100	2 904	2·379
40	3·323	2·678	2·600	1·159
45	2·986	1·428	1·250	
50	2·650			
55	1·472			
No. of Verticals	11	32	18	14

* Annales des Ponts et Chausses, tome xx, 1847, page 362.

TABLE XI—*Continued.*

NIAGARA RIVER.

Depth.	69·9 feet.	56·1 feet.	53·2 feet.	44·1 feet.
	3 169	3·125	3·376	2·577
5 ft.	3 239	3·195	3·446	2·647
10	3·279	3·184	3·347	2·601
15	3·261	3 081	3·171	2·499
20	3·154	3 085	3·209	2·291
25	3·124	2·858	3·108	2 225
30	3·083	2 815	2·957	2·153
35	3·037	2·765	2·809	1·996
40	2·842	2·594	2·499	1·670
45	2·760	2·371	2·321	0·652
50	2·651	1·877	1·766	
55	2·333	1·252	0 931	
60	2·014	0·807		
65	1·654			
70	0·552			
No. of Verticals	8	15	31	10

TABLE XI—*Continued.*

ST. LAWRENCE RIVER.

Depth.	83·0 feet.	65.2 feet.	46.1 feet.	42·5 feet.
5 ft.	1·638	1·533	1·332	1·176
10	1 609	1·509	1·320	1·194
15	1·596	1·507	1·369	1·143
20	1·602	1·470	1·292	1·075
25	1·569	1·477	1 280	1·065
30	1·549	1·417	1·214	0·969
35	1·576	1·398	1·153	0·874
40	1·521	1·357	1·007	
45	1·486	1·315		
50	1·483	1·236		
55	1·500	1·167		
60	1·504	1·092		
65	1 385			
70	1·289			
75	1 180			
80	1·202			
85				
No. of Verticals	4	66	14	5

These velocities are plotted in figures 9, 10 and 11, being represented by the circumscribed dots.

In the deeper verticals, the velocities near the surface plot nearly

in a perpendicular line, while in those of less depth the velocities incline more from the surface. It was found that an ellipse whose minor axis was at or near the surface, with the vertex a little below the deepest vertical, would pass through nearly all the plotted points of that vertical, and by raising the minor axis above the surface would also pass through the plotted points of the other verticals at the same station, except in those very near the banks, the velocities there decreasing too rapidly from the surface. This ellipse is shown by the full line in the figures, being the same curve for the St. Clair and Niagara, but more eccentric for the slow and deep current of the St. Lawrence.

In figure 12 the velocities across the river St. Clair, at different depths, are plotted. These were obtained by taking the mean of all the observations every fifty feet across the river at the several depths.

As these measurements were made on different days, the means would not probably show as regular a curve as the verticals, where one or more series were taken during the same day.

They are given only to show that the same form of curve satisfies the velocities in a horizontal as well as in a vertical plane, the full lines representing two semi-ellipses meeting in the "Thalweg," or deepest part of the river.

As we have seen, the curve adopted in the Mississippi observations was a parabola with its axis three-tenths the depth below the surface.

To compare the observations on these rivers with this curve, two verticals were selected, one in the St. Clair and one in the St. Lawrence. These verticals were chosen, partly because they were the mean of the largest number of observations, and partly because, not being the deepest verticals in the rivers, the velocities were not so nearly equal near the surface, and therefore would compare more favorably with the parabola. Also, instead of taking the axis at three-tenths the depth, it was assumed at five feet from the surface, or one-ninth the depth in the first vertical, and one-thirteenth in the second.

(To be continued.)

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LXII, page 391.)

"In the present experimental state of the introduction of pulleys and belts, moving with high velocities for the transmission of power

to a distance from motors, a few facts may be briefly stated to inspire confidence in the operators of mills to adopt new arrangements by learning what has been found practically successful.

"A good leather belt, one inch wide, has sufficient strength to lift 1000 lbs.

"The speed of a mile per minute for main driving leather belts has been found both safe and advantageous for practical use.

"The capability of belts to transmit power is determined by the extent of its adhesion to the surface of pulleys.

"The extent of adhesion of belts varies greatly under varying circumstances of the use of them, and is very limited in comparison with the absolute strength of the leather.

"The adhesion and friction, causing the belt to cling to the surface of a pulley without slipping, is mainly governed by the weight of the leather,—if used horizontally.

"If belts are strained tightly on the pulleys, then the adhesion is increased in proportion to the increased tension produced.

"The weight of leather in vertical belts tends to produce a sag beneath the under side of the under pulley; and, if loosely put on, might not touch it at all, to tranmit power by adhesion. For this reason it is necessary to strain on more tightly all vertical belts, with a dependence on the elastic stretch of the leather for producing adhesion.

"A vertical belt of single leather of the width of six inches, and with a velocity of 5200 feet per minute, has practically been used very satisfactorily at the Georgia mill, during several years, to operate 10,400 self-acting mule-spindles, and the spoolers and warpers for the same; and another belt of similar width and velocity, 110 feet in length, has served to transmit the power from a 24-feet water-wheel, 18 feet long, under a fall of 20 feet, with the same velocity of 5200 feet.

"A 24-inch belt of single leather, with the velocity of 4850 feet per minute, has transmitted all the power of a steam engine of six-feet stroke, thirty-inch cylinder, making forty revolutions per minute, and wich so slack a tension on the returning side as to flap and wave with an undulating movement.

"These statements are specified simply to show what has been done by belts running with certain velocities,—not for the purpose of holding them up as models for imitation.

"No fixed rule can be gived for calculating the actual adhesion of belts; for this adhesion depends upon so many contingent facts of their relative positions and weights, as affected by greater or less lengths and breadths, and lightness. As the result of experimental observations, it may safely be calculated that, with a properly slack belt, the effective adhesion of a horizontal belt may be taken at 30 lbs. to each inch of width of short belts, and double of this on long belts, with threefold or more if tightly strained on the pulleys, which never should be done; for this increases the friction of the bearings and waste of power, in addition to injuring the durability of the leather for service.

"Clamps with powerful screws are often used to put on belts with extreme tightness upon the pulleys, and with most injurious strain upon the leather. They should be very judiciously used for horizontal belts, which should be allowed sufficient slackness to move with a loose undulating vibration on the returning side, as a test that they have no more strain imposed than what is necessary simply to transmit the power.

"Rather than to continue to use horizontal belts with overstrained tightness to obtain the necessary adhesion, it is often better to use larger pulleys, which require less adhesion to transmit an equal extent of power.

"On the scientific principle that the adhesion, and consequently the capability, of leather belts to transmit power from motors to machines is in proportion to the pressure of the actual weight of the leather on the surface of the pulley, it is manifest that, as longer belts have more weight than shorter ones, and that broader belts of the same length have more weight than narrower ones, it may be adopted as a rule that the adhesion and capability of belts to transmit power is in the ratio of their relative lengths and breadths. A belt of double the length or breadth of another, under the same circumstances will be found capable of transmitting double the power. For this reason it is desirable to use long belts. By doubling the velocity of the same belt its effectual capability for transmitting power is also doubled."—*Z. Allen, Esq., Providence, R. I., in Proceedings of N. E. Cotton Mfrs.' Ass., No.* 10.

ON THE EXPLOSION OF STEAM BOILERS.

By Wm. M. Henderson, Hydraulic Engineer.

In response to an invitation received from Mr. Francis B. Stevens, Engineer of the United Railroad Companies of New Jersey, to witness a continuation of the experiments relating to the causes of steam boiler explosions, the Franklin Institute sent a committee, Nov. 22d, to the United States reservation at Sandy Hook, composed of the following members: Messrs. Coleman Sellers, President; W. H. Wahl, Secretary; Jacob Naylor and W. M. Henderson, Mechanical Engineers.

Upon arrival at the destination there were found nine steam boilers, within a board-fence enclosure, each set up with smoke stack complete, and fired up, ready for the test of their endurance.

The circular which is here appended will suffice to furnish all the data for a proper understanding of the results of the trials:

Office of the Camden and Amboy Shops,
Foot of Second Street,
Hoboken, New Jersey, Nov. 22d. 1871.

To the gentlemen invited to be present at the experiments made by the United Companies of New Jersey, on Wednesday, Nov. 23d, 1871, at Sandy Hook:

On the 11th of September last, the Executive Committee of the Companies passed the following resolutions:

"That, in order to attain greater safety in the steam boilers belonging to the United Companies, Mr. F. B. Stevens be authorized to continue the experiments on the strength and proper management of such boilers and for this purpose to expend not exceeding ten thousand dollars, the vouchers for which to take the ordinary course.

"That other owners of steam boilers are hereby invited to contribute to the experiments to be made by Mr. Stevens; and that the wharf, shops, derrick, or tools belonging to the United Companies at Hoboken may be used for this purpose, at cost prices, and a copy of the charges given by the Auditor to the contributors.

"That Mr. Stevens be advised to invite the United States Inspectors, and other prominent engineers, to be present at the experiments."

And on the 20th of the same month I received permission from the Secretary of War, at the instance of the President, to make the experiments on the Government reservation at Sandy Hook.

The boilers to be experimented on are nine in number, and each boiler has its number painted on it in large figures. Nos. 1, 2, 3 and 4 are the four steamboat boilers that were burst by hydrostatic pressure, at Hoboken, on September 2d, an account of which was widely published in the daily papers. The injury done was so small that they have since been repaired, at an average cost of less than $100 for each boiler.

No. 1 and No. 2 are a pair; they were built by Fletcher, Harrison & Co. in 1858, and were taken out of the boat last July, after having been in use 13

years. They are the ordinary return-flue boilers, identical in shape and general construction with the Westfield's boiler, but smaller. They are 28 feet long, and the shell is 6 feet 6 inches in diameter. They were tested by hydrostatic pressure, in their present position, at Sandy Hook, to 82 lbs., without fracture, on the 4th of November, and on the 15th of November they were subjected to steam pressure—No. 1 to 25 lbs. and No. 2 to 60 lbs. per square inch, without fracture.

No. 3 was built by T. F. Secor, in 1845; was taken out of the boat in August last, after having been in use 25 years. When taken out, the certificate allowed 301 bs. per square inch. It is a return tubular boiler, with the furnace the whole width. It is 12 feet wide by 15 feet 5 inches long.

The crown of the furnace is flat, and braced to the shell by crow feet braces. On September the 2d twelve of the crow-feet gave way under a hydrostatic pressure of 60 lbs. After being repaired it was subjected to a hydrostatic pressure—in its present position at Sandy Hook, on November 4th—of 59 lbs. per square inch, without fracture; and on November 16th it was subjected to a steam pressure of 45 lbs. per square inch, without fracture.

No. 4 was built by H. R. Dunham & Co., in 1849. It was taken out of the boat in July last, after having been in use 21 years. When taken out the certificate allowed 40 lbs. per square inch. It is a return tubular boiler, the same as No. 3, but with a centre leg. It was subjected to a steam pressure of 62 lbs. without fracture.

No. 5 is a cylindrical boiler, without flues built for these experiments. It is 80 inches in diameter and 10 feet long, the heads being flat. The iron is all $\frac{5}{16}$ inch thick; part of the shell is made of Pennock's best flange iron, and part of Pennock's Eureka, as painted on the boiler. One head is made of Pennock's Eureka iron, and the other head of the Abbott Iron Company's best flange fire box. The heads are braced by rods of best imported Norway iron, $\frac{5}{8}$ inch in diameter and 10 feet long, and spaced in squares 6 inches apart, over the whole surface of the heads. These braces are screwed into each head, and also have a nut on the outside of each head. The longitudinal seams are double riveted. The object here has been to construct a boiler of nearly uniform strength throughout. Flat heads, braced across from head to head, were adopted instead of hemispherical ends, to prevent the rivets of the shell from being subjected to a cross strain. The boiler was tested by hydrostatic pressure to 172 pounds, without fracture, and it has been tested by steam up to 75 pounds, in its present position.

No. 6 is a flat surface, 6 feet long, 4 feet high and 4 inches wide, built for these experiments, and copied after the back end of the Westfield's boiler. It is made of the Abbott Iron Company's best flange fire box. The plates are the same thickness as the Westfield's, viz., $\frac{5}{16}$ thick, and the stays connecting these plates are the same diameter as the Westfield's, viz., $1\frac{1}{8}$, with the same sized thread, and they are spaced in the same manner and at the same distance apart that the Westfield's are. Care has been taken to make the riveted heads of these braces as nearly as possible like those of the Westfield's. This piece of a boiler has been subjected to a hydrostatic test of 138 lbs. per square inch, without fracture, and to a steam pressure of 102 lbs. per square inch, in its present position at Sandy Hook.

Nos. 7 and 8 are small upright boilers, nearly new and very strong, being two feet in diameter, and built of iron $\frac{1}{4}$ of an inch thick. They have been subjected to a hydrostatic pressure of 180 lbs., without fracture No. 9 is a cylindrical return tubular boiler, 42 inches in diameter and 8 feet long, and it has been subjected to a hydrostatic pressure of 180 lbs., without fracture.

The four steamboat boilers have been repeatedly burst by hydrostatic pressure, and repaired; and they are undoubtedly able now to bear a much greater pressure without fracture than they were when taken out of the boats. But the question is, have they been overstrained? for the object has been to ascertain to what extent boilers of the form tried are overstrained when the margin for safety between the test pressure and the pressure allowed is two to one

The intention is to try all these boilers with the safety-valves fastened down or removed, so as to allow the steam gradually to increase until a rupture takes place. On the four steamboat boilers the intention is to ascertain and compare the difference in the ruptures that were produced by hydrostatic pressure with those produced by steam gradually accumulated, and also to ascertain and compare the differences of the ruptures produced by steam gradually accumulated with those produced in experiments to be tried at a future day with the water low. On No. 5 the intention is to try what effect the gradual accumulation of steam to the point of rupture has on the rivets and seams of a new boiler, made nearly equal in strength throughout. On No. 6 the intention is to endeavor to approximate to the pressure per square inch required to tear the back of the Westfield's boiler from the stay-bolts. On Nos. 7, 8 and 9 the intention is to endeavor to corroborate the experiments on No. 5.

The boiler of the Westfield has been purchased from Mr. John Roach, who with liberality and forethought saved it from being cut up. If the experiments are continued, it is proposed to repair the Westfield's boiler, and then to endeavor to ascertain by trial the pressure at the instant of explosion, and also to ascertain whether the explosion was produced by a pressure gradually accumulated, or by one suddenly produced. The question as regards the Westfield is a simple one. Was the disaster caused by want of strength in the boiler? or was it caused by so sudden an accumulation of pressure, produced by low water, that an increase of the strength of the boiler would have only added to the disaster? On this point engineers differ; but, taking the fact into consideration that nearly all the ferry-boats in the harbor of New York have boilers identical with the Westfield's, the question should be settled so that not the shadow of a doubt should remain.

FRANCIS B. STEVENS.

Outside the enclosure were two large fresh-water tanks, for supplying the boilers with water. A number of steam gauges were also arranged upon one side of the fence, the highest graduated to indicate 500 lbs. to the square inch. As it would have been impracticable, however, to refer to these upon the final bursting of each boiler, there were erected, at a distance of 250 feet, two other gauges, one indicating to 100, the other 500 lbs. per square inch, the latter being a mercury gauge. At this stand all retreated to witness the expected explosions.

The experiments commenced with boiler No. 2. The fuel used was wood, and a quantity was packed in the furnaces, of which there were two, sufficient it was considered to generate steam enough to cause explosion, there being no safety valve or any possible avenue of escape for the steam, except through the sheets composing the boiler. The pressure slowly gained until there was indicated upon the gauges situated at the safe point of observation a pressure of about 65 lbs., at which time small wreaths of steam could be observed escaping from the seams. This was followed by a quantity seen to escape from the smoke stack, indicating a leak, probably, in the furnaces. As the pressure rose the escape of steam from the seams increased, until a pressure of 92 lbs. was reached, when the volume discharged became greatly increased, and could be heard quite audibly at the indicator stand. The pressure went up to 93 lbs., but here the leak was so great, it became apparent the fire had gained its maximum and a vent had been created sufficiently large to carry off the steam as promptly as it was generated. From this point the indicators of the gauges began a retrograde movement, and after a lapse of about 20 minutes the boiler was approached and the fires smothered with sand—a wise precaution, as an attempt to draw the fires might have accelerated the generation of steam with disastrous effect. The appearance then presented by the boiler was probably more instructive and of far greater significance to the professional engineer than if an explosion had actually taken place. Here was a boiler on the very verge of destruction, saved almost by a miracle, to illustrate the manner in which some boilers take the initiative step to explosion.

This boiler was of the return-flue description, the smoke-stack passing through the steam drum. Looking at the point of leak, which was at the rear of the steam-drum, where it joins the shell, it was discovered that the shell at this point had been visibly drawn downwards. This naturally drew attention to the furnaces, and, as might be reasonably inferred, both crown sheets, originally flat and stayed to the roof of the outside shell, had been forced down and bulged in the center of each, between two rows of the stays referred to, to an extent of about two inches, pulling the outside shell with it, as represented, away from the lower sheet of the vertical steam-drum, thus opening a seam, venting the boiler, and alone saving it from destruction. Had the boiler exploded, the starting-point would have been a matter of conjecture. Here we have it to a certainty. A little more pressure would have completed the destruction of this boiler, each fragment of

which more than likely would have found an advocate ready to prove it to be the incipient cause of the catastrophe. The giving way at this point was no doubt caused by the shell being there weakened by the large amount of metal cut out to accommodate the steam-drum, and would suggest the addition of a stiffening ring at such locations. It cannot be denied, however, but that the boiler was well proportioned in all its parts, and showed an admirable power of endurance.

The second experiment was made with water-leg No. 6. The fuel used and manner of conducting this experiment was the same as pursued in the case of No. 2. The structure was placed, edgewise, between two brick furnaces, and flanked by a brick wall on each side. The pressure, as indicated by the gauges, rose quite rapidly after the steam began to form, increasing from 44 lbs. to 100 lbs in ten minutes, and subsequently at the rate of about 10 lbs. per minute. In seven minutes more the pressure had accumulated to 165, at which point explosion took place, with a loud report, the sides parting right and left, the former being projected through and carrying away part of the wooden fence, and lodging in the sand distant about 125 feet. The latter half caused more mischief, in its career striking the fire-box of boiler No. 3, knocking a large hole in it, and liberating its steam, preventing that boiler from being subjected to further experiment for the time being. The brick furnaces and walls were utterly demolished, and many of the bricks were hurled with fearful violence to within a few feet of where the spectators stood by the indicator gauges.

Upon an examination of the sheets they were found to be much bellied and contorted. The wrought-iron frame through which the rivets passed, binding the edges, was found to have been made in four pieces, mitred at the corners, the joints having been made with great care. This proved to be a very bad arrangement, for some of the corners of the sheets, which should have been the strongest parts, were ripped diagonally towards the centre, plainly showing all such distance pieces should be *welded*. The direct cause of this explosion was very apparent and readily traced to the general insufficiency of the riveting. The rivets were placed two inches apart, the heads being merely turned over. The same was the case with the stays. These were $1\frac{1}{8}$ inch in diameter, placed about $8\frac{1}{2}$ inches apart. Parts of the plates were torn through the line of rivets; but the great fault existed in the poor specimen of boiler workmanship. It seemed so eminently absurd to select stays so large as $1\frac{1}{8}$ inch, and then merely

insert them through the two sheets, with no more hold than the little afforded by the amount of screw thread to be obtained in boiler plates of but $\frac{5}{16}$ inch thickness, the riveting amounting to almost nothing. A section such as this secured by socket bolts, riveted hot, or by screw nuts, would have withstood a pressure of 400 lbs. to the square inch. As it was, this badly constructed part was as strong as the rest of the boiler, and it only proves that flat surfaces, properly stayed, are the strongest parts of our steam boilers.

In connection with these experiments there was made manifest a very beautiful illustration of the directions taken by the strains upon the sheets. It was observed there were lines proceeding from one stay to the other, by a system of mathematical convolute curves spaced about one-sixteenth of an inch apart in the widest range. As these crossed each other, diverging from one stay to another, the effect was very beautiful, resembling in form the rays thrown off by the pyrotechnic pin-wheel, so familiar to our readers. This appears to present a new field for scientific discussion, and may lead to important results, if the phenomenon can be successfully accounted for. We hope some of our scientific readers may be enabled to throw some further light upon this truly remarkable subject.

[In continuation of the same subject, the following circular letter, addressed to the Hon. Secretary of the Navy by the Chief Engineers, whose names are attached, contains a confirmation of the preceding, as well as much additional information of interest to engineers. A memorial, signed by the most prominent scientific names throughout the country, will shortly be presented to Congress, with the object of securing Government aid for a thorough investigation of this all-important subject:—ED.]

NEW YORK, December 12th, 1871.

SIR,—Agreeably to your orders of the 18th ultimo, appointing the undersigned a Board to witness, report upon, and give all necessary information relating to the experiments being made at Sandy Hook, New York, by Mr. Francis B. Stevens, of Hoboken, New Jersey, on steam boiler explosions, we have the honor to submit a description of them as far as they have progressed, accompanied by our observations on their results.

The experiments referred to were devised by Mr. Stevens, in pursuance of the following resolutions, passed on the 11th of September last by the Executive Committee of the United Railroad Companies of New Jersey, namely:

"That, in order to attain greater safety in the steam boilers belonging to the United Companies, Mr. F. B. Stevens be authorized to continue the experiments on the strength and proper management of such boilers, and for this purpose to expend not exceeding ten thousand dollars, the vouchers for which to take the ordinary course.

"That other owners of steam boilers are hereby invited to contribute to the experiments to be made by Mr. Stevens: and that the wharf, shops, derrick and tools belonging to the United Companies at Hoboken may be used for this purpose at cost prices, and a copy of the charges given by the Auditor to the contributors.

"That Mr. Stevens be advised to invite the United States Inspectors, and other prominent engineers, to be present at the experiments."

On the 20th of September last, Mr. Stevens received permission from the Secretary of War, at the instance of the President, to make the experiments on the Government reservation at Sandy Hook, and to that place he transported the experimental boilers, with the necessary instruments, material and shed accommodation.

The boilers to be experimented with were nine in number; they were conveniently arranged on a well-chosen piece of ground enclosed by a high board fence, and were provided with the requisite pressure and water gauges. The former were expressly manufactured for the occasion, and had been carefully tested. Five pressure-gauges were placed near each boiler tried, under the protection of two bomb-proof; and two, tested to a pressure of 500 lbs. per square inch, were placed side by side at a safe distance from the boilers (about 250 feet on the first day, and 450 feet on the second day of the experiments) with which they communicated by a pipe of suitable length; while in this position, their indications were compared with those of the tested pressure-gauges at the boilers, and found to agree. All of Mr. Stevens' arrangements were judiciously made, and nothing was wanting to their accuracy and completeness.

Experiments on the 22d of November, 1871.

On the 22d ultimo, in accordance with a notification from Mr. Stevens, we proceeded to Sandy Hook and witnessed the first experiments in company with the following gentlemen, who are largely interested, practically and scientifically, in the design, construction and use of steam boilers:

Joseph Belknap, Inspector General of Boilers; H. Birdsall, Inspector of Boilers; R. B. Davenport, Reporter for the New York "Herald"; J. B. Collin, Mechanical Engineer of the Pennsylvania Central Railroad; Coleman Sellers, President of the Franklin Institute, Philadelphia; Dr. Wm. H. Wahl, Secretary of the Franklin Institute, Philadelphia; Jacob Naylor, of Philadelphia; Wm. M. Henderson, of Philadelphia, Mechanical Engineer; E. H. Shallcross, of the Select Council of Philadelphia; Wm. Fisher Mitchell, of Philadelphia; Thomas J. Lovegrove, of Philadelphia; R. H. Thurston, Prof. Mechanical Engineering, Stevens' Institute, Hoboken; A. Fletcher, W. Fletcher, Builders of Steam Engines and Boilers at New York; C. H. Haswell, Examiner of Steam Machinery for the New York Insurance Companies; Norman Wiard, John McCurdy, James Miller, Messrs. Phinney & Hoffman; David Saunders, of the firm of J. Nason & Co., New York; Erastus W. Smith, Mechanical Engineer; W. E. Worthen, Mechanical Engineer; Robert Allen, Ralph Walker, G. H. Clemens, John Stuart, C. M. Bolen, T. S. Crane, John Dunham, Andrew Fife, John Fish, John McGowan.

The first experiment was made on a boiler built by Fletcher, Harrison & Co., in 1858, and taken out of the steamboat "Joseph Belknap" in July last, after having been thirteen years in use. It is of the ordinary upper return-flue type

with a rectangular front, 7 feet 8 inches long, 6 feet 6 inches wide, and 6 feet 11 inches high, containing two furnaces, each of which was 2 feet 9 inches wide and 7 feet long; the top of this front is semicircular and single riveted. The remainder of the shell is a cylinder of 6 feet 6 inches diameter and 20 feet 4 inches length, unbraced, single riveted, and with a flat end. The total length of the boiler is 28 feet. The iron of which the shell is composed is a large $\frac{1}{4}$ inch thick, and all the flat surfaces are braced every 7 inches. The top of the furnaces is flat and braced to the semicircular top of the shell immediately over it; and from this semicircular top there rises the usual cylindrical "steam chimney" or annular steam-drum, surrounding the lower portion of the chimney and braced to it. The steam chimney is 4 feet in external diameter, 2 feet 8 inches in internal diameter, and 10 feet 5 inches in height above the shell. The lower flues are ten in number, and 15 feet 9 inches long; two of them are 16 inches in inner diameter, and the remainder are 9 inches in inner diameter. The upper flues are 12 in number, 22 feet long and $8\frac{1}{2}$ inches in inner diameter. The least water space between the flues is $2\frac{3}{4}$ inches in the clear. All the flat water spaces of the boiler are 4 inches wide, including thicknesses of metal. The grate surface is $38\frac{1}{2}$ square feet. The water-heating surface in the furnaces is 80·09 square feet; in the combustion chambers, 31·84 square feet; in the lower flues, 428·70 square feet; in the back connection, 76·92 square feet; in the upper flues, 587·48 square feet; and in the front connection, 57·98 square feet; making a total water-heating surface in the boiler of 1,263 square feet. The steam superheating surface in the steam chimney is 84 square feet.

This boiler, on the 2d of September last, was subjected, at Hoboken, to a hydrostatic pressure of 112 pounds per square inch, which broke a few of the braces without altering the form of the semicircular top of the rectangular front. After being repaired, it was again subjected, at Sandy Hook, on the 4th of November last, to a hydrostatic test of 82 pounds per square inch, without the rupture of any part; and on the following 15th of November it was subjected to a steam pressure of 60 pounds per square inch, without fracture.

In the experiment of the 22d of November, which we witnessed, the fuel used was wood, and it was intended to burst the boiler by steam pressure under the condition of 12 inches of water above the top of the flues, but it was found that the pressure could not be raised above 93 pounds per square inch, owing to the excessive leakage of steam from the seam joining the steam chimney to the boiler shell. At the above pressure no fracture occurred, but the form of the semicircular top of the rectangular front underwent a change. The experiment was only of value in showing the strength of a boiler of this type and construction after thirteen years' service in a vessel.

The next experiment was made on a rectangular box, built to represent the flat water space or water-leg of the "Westfield's" boiler, recently exploded at New York on board that vessel, with great destruction of property and life.

This box was 6 feet long, 4 feet high, and 4 inches wide, over all. The two side plates were of the best flange fire-box iron, $\frac{5}{16}$ of an inch thick, manufactured by the Abbott Iron Company. The plates were held together by a single row of rivets at their edges, passing through a frame made of wrought iron bars, mitred at their ends, and having the same outside dimensions as the box. These bars were $3\frac{5}{8}$ inches wide, 2 inches deep, and perforated at the centre line by the

holes for the rivets. The side plates were braced together, every $8\frac{1}{4}$ inches one way and $9\frac{1}{5}$ inches the other way of their surface, by bolts of $1\frac{1}{8}$ inch diameter, with threads cut upon each end and screwed into corresponding threads cut in the plates, over which both ends of the bolts were slightly—and but very slightly—riveted. The box was placed on one edge upon an 8 inches thick brick wall, and was enclosed with side walls of brick masonry, with the exception of a strip 15 inches deep at the top and 12 inches wide at one side, which protruded into the air, and to which the gauges were attached. The enclosed portion of the box was heated by two small furnaces without intercommunication, the fire grates of each being 27 inches long and 14 inches wide. The fuel was wood, and the products of combustion were discharged through two sheet-iron pipes. The surface of the box exposed to the fire was $19\frac{1}{2}$ square feet, and was all water-heating surface, as the box was filled with water to within nine inches of its top. Of the total interior height of the boiler, therefore, 37 inches were occupied by water and 7 inches by steam.

The fires being brought to steady action, and steam raised to the atmospheric pressure, the opening for the escape of the latter was closed, and the pressure rose as follows, for the corresponding times, namely:

Time P. M. Hours.	Time P. M. Minutes.	Steam pressure in pounds per square inch above the atmosphere.	Time P. M. Hours.	Time P. M. Minutes.	Steam pressure in pounds per square inch above the atmosphere.
3	18	0	3	36	51
3	20	4	3	37	54
3	21	5	3	38	58
3	22	7	3	39	65
3	23	9	3	40	72
3	24	11	3	41	78
3	25	13	3	42	86
3	26	15	3	43	94
3	27	18	3	44	100
3	28	20	3	45	110
3	29	23	3	46	117
3	30	27	3	47	126
3	31	30	3	48	135
3	32	34	3	49	147
3	33	38	3	50	160
3	34	44	3	51	165
3	35	49			

When the pressure reached 165 pounds to the square inch, the box exploded with a loud report, completely demolishing the brick-work by which it was enclosed. The two sides were hurled in exactly opposite directions, and to about equal distances, at right angles to their surfaces. The fracture had occurred in one plate only, and was along the whole riveted seam joining it to the frame. For a large part of the length of the seam, this plate was torn out between the rivets, and for the remaining part the rivets were sheared. The other plate was not fractured, nor were the bars of the frame broken; the plate and the frame remained riveted together, but not uninjured—all the bars of the latter being bent considerably inwards, forming an irregular curve of from four to six

inches versed-sine. Both plates were bulged out irregularly, so as to be about nine inches dishing, and the bulging took place near the bars. Not one of the bolts was broken, and neither the threads upon their ends, nor the threads in the plate, were stripped or injured, but the slight riveting over of the ends of the bolts was broken off in all of them.

The fact that the plates did not rupture at the centre, under their great amount of bulging, (and only one of them tearing off at the line of rivets along its edge,) shows the excellence of the metal which endured this great, almost instantaneous, and permanent stretching without fracture; and to this same extensive stretching must be attributed the escape of the screw threads on the ends of the bolts, and in the plates, from injury. The plate, by stretching, simply enlarged the diameter of the hole in which the threads were cut, until the bolt, thus left free, slipped through without injury to its threads, only breaking off the slight riveting over of its ends. Had these bolts been secured by nuts on the outside of the plates, the box would have borne an enormously greater pressure than that which exploded it. Between the bolts there was a small permanent stretching of the plates, giving each space between the bolts a slightly dishing or bulged form, in addition to the general bulging of the plates, thus forming a system of secondary bulges, as it were; and around every bolt both plates were strongly marked by a congeries of circular crispations.

The conclusions from this experiment are: That a gradually accumulating steam pressure in a boiler can produce a true explosion, violently hurling its fragments, with a loud report, to a considerabe distance, even though 84 per centum of its capacity be filled with water; and—That screw bolts should not be used in boiler construction without nuts, or having, as an equivalent, a large portion of their ends formed into massive rivet heads; because the stretch of the plates is sufficiently great, under a much less pressure than will fracture the bolts or strip their threads, to allow the latter to slip through uninjured.

Previous to this experiment, the box had been subjected, at Sandy Hook, to a hydrostatic pressure of 138 pounds per square inch, and to a steam pressure of 102 pounds per square inch, without fracture.

Experiment on the 23d of November, 1871.

On the 23d ultimo, a last experiment was made by exploding a boiler in the presence of the undersigned and the following gentlemen, namely:

Capt. W. W. Woolsey, Superintendent of the Jersey City Ferry; William and Andrew Fletcher, of the firm of Fletcher, Harrison & Co., Engine and Boiler Makers; Anning Smith, Superintendent of the North Shore Ferry Company; J. B. Collin, Mechanical Engineer of the Pennsylvania Central Railroad; William A. Dripps; Thomas Lingle, of the Camden and Amboy Railroad; Wm. Brown, of the Camden and Amboy Railroad.

The boiler that was exploded during this experiment was built by T. F. Secor in 1845, and taken out of the steamboat "Bordentown" in August last, after having been 25 years in use. When taken out, the Inspector's certificate allowed it to be worked with a pressure of 30 pounds per square inch. It was a horizontal fire-tube boiler, with the tubes returned immediately above the furnace and combustion chamber.

It had but one furnace, and that was 11 feet 5 inches in width, with grate bars 7 feet in length The top of the furnace and the top of the combustion chamber were flat, and braced to the flat top of the shell above them by rectangular braces 2 inches by ½ inch in cross section, placed 17 inches apart crosswise the boiler, and 12 inches apart lengthwise the boiler, each brace holding a flat surface of 204 square inches, to which it was attached by crow-feet so arranged that the flat surface between the sustaining rivets was 12 inches square. The flat water-spaces were braced at intervals of 8 inches in one direction and 12 inches in the other, by 1 inch diameter screw-bolts, each of which held a flat surface of 96 square inches. The iron plates of the boiler were a large ¼ inch thick.

The tubes were of iron, and 384 in number, arranged in 8 rows vertically and 48 rows horizontally. Each tube was 2 inches in outside diameter and 12 feet in extreme length. The total height occupied by the tubes from the lower side of the lower tube to the upper side of the upper tube, was 22 inches. The tubes were divided into sixteen groups, and the groups were separated by water spaces two and one-sixteenths inches wide in the clear vertically, and 1¼ inch wide in the clear horizontally. From the lower side of the lower row of tubes to the top of the furnace and combustion chamber, was a space six inches in width, for water circulation. The bridge-wall and the bottom of the combustion chamber were of brick. The furnace had no water-bottom, but its side legs of 4½ inches width rested in a pan which covered the entire area beneath the furnace.

The shell of the boiler was rectangular with the exception that the vertical sides were joined to the flat top of quadrantal arcs of 37 inches radius. All the seams were single riveted.

Upon the centre of the top of the boiler was a cylindrical steam drum of 6 feet diameter and 8 feet, 8 inches height.

The flat water-space at the front of the furnace was 4½ inches wide, and that at the back end of the boiler was 5 inches wide, including thicknesses of metal.

The width of the boiler was 12 feet 2 inches, its length was 15 feet 5 inches, and its height, exclusive of the steam-drum, was 8 feet 6 inches.

The shell was braced very unequally. Each upper horizontal brace, 1¼ inch large in diameter, sustained the pressure upon a surface 28 by 12 inches or 336 square inches; and each rectangular vertical brace adjacent the sides, 2 inches by ½ inch in cross section, sustained the pressure upon a surface 19 by 12 inches or 228 square inches; these were the weakest places.

The following were the grate and water heating surfaces of the boiler:

Grate surface	79 $\frac{11}{12}$	square feet.
Heating surface in furnace	180	"
" " in combustion chamber and back connection	103	"
" " in tubes	2171	"
" " in uptake	64	"
Total heating surface	2518	"

On the 2d of September last, this boiler was subjected to a hydrostatic pressure of 60 pounds per square inch, when twelve crow-feet gave way. After being repaired, it was again subjected on the 4th of November last, when erected at Sandy Hook, to a hydrostatic pressure of 59 pounds per square inch.

which it bore without fracture; and on the 16th of November last, it was subjected to a steam pressure of 45 pounds per square inch, which it also sustained without fracture.

The fuel used in the experiment was wood, and the water-level in the boiler was 15 inches above the highest point of the tubes. When the fire had been brought to steady action, the pressure of the steam gradually increased at the following rate, commencing with the pressure of 29½ pounds per square inch:

Time P. M.		Steam pressure in lbs. per square inch above the atmosphere.	Time P. M.		Steam pressure in lbs. per square inch above the atmosphere.
Hours.	Minutes.		Hours.	Minutes.	
12	21	29½	12	30	46½
12	23	33½	12	31	48½
12	25	37½	12	32	50
12	27	41	12	33	52
12	29	44½	12	34	53½

At the pressure of 50 pounds per square inch, some of the braces in the boiler gave way with a loud report, and when the pressure of 53½ pounds was reached, the boiler exploded with terrific violence. The steam-drum and a portion of the shell attached to it, forming a mass of about three tons weight, were hurled to a great height in the air and fell to the earth at about 450 feet from the original position of the boiler, crushing several trees in their fall. Two other large fragments fell at less distances, while smaller ones were thrown much farther. Almost the whole of the boiler was literally torn into shreds which were scattered far and wide, the only portion remaining where the boiler had been, being the tubes. These, though considerably distorted, were otherwise uninjured. Both tube-plates had been blown from the tubes in opposite directions, and at the same moment, for nearly all the tubes were found lying in a heap on the ground immediately beneath the place they had occupied in the boiler, the riveting of their ends over the plates having been simultaneously stripped. The top of the furnace and the top of the combustion chamber, which, in the boiler, were immediately beneath the tubes, had entirely disappeared into débris, as had also the sides and ends of the shell. The boiler seems to have first yielded by the fracture of the upper row of horizontal braces. The loud report heard when the pressure obtained 50 pounds per square inch was probably caused by their breaking. The larger masses were all thrown in one direction—at right angles to the side of the boiler; but the smaller fragments were projected radially in all directions, as from a centre. Two heavy bomb proofs, constructed of large timbers and sand for the protection of the other boilers, were dislodged and a part of the fence of the enclosure was destroyed, by the impact of the flying fragments. The crow feet, in most cases, remained firmly attached to the shell, and the braces had parted—probably in the welds—leaving the ends still secured to the crow feet. The screw bolts which braced the flat water spaces, had slipped from their fastenings in the plate without injury to the screw threads either upon them or in the plate. The latter was permanently bulged or dished between the bolts, and this stretching of the metal had, by its enlargement of the holes, allowed the screw ends of the bolts to draw out without injury to the threads, either on the bolts or in the plates.

The ground beneath, and for a considerable distance around where the

boiler stood, was saturated with the water of the boiler, in fact made into mud, and the adjacent grass and small shrubbery were so drenched that an ordinary boot was wet through by walking among them. At seven minutes before the explosion took place, the water gauge on the boiler was examined and found to indicate the water level 15 inches above the top of the tubes.

The conclusions to be drawn from this experiment are the following:

1st. An old boiler, containing a large mass of water above the highest point of its heating surface, can be exploded with such complete destruction as to reduce it into mere debris, and hurl the fragments in all directions with a force that no ordinary construction of building or vessel could withstand.

2d. That the pressure required for so devastating an explosion, is the very moderate one of 53½ pounds per square inch.

3d. That with only a wood fire, generating a far less quantity of heat in equal time than a coal fire, there were required only thirteen minutes to raise the pressure from the Inspector's working allowance of 30 pounds per square inch, to the exploding pressure of 53½ pounds per square inch, showing that a few minutes absence or neglect of the engineer, coupled with an overloaded or inoperative safety valve, are all that are needed to produce the most destructive steam boiler explosion, even with an old and unequally braced boiler, in which it might be supposed a rupture of the weakest part would precede other fracture, and allow the reduction of the pressure without doing further injury.

4th. That in accounting for either the fact of an explosion, or for its destructive effects, there is no necessity for hypotheses of low water, enormous pressures, instantaneous generations of immense quantities of steam, superheated steam, the formation of hypothetical gases, development of electricity, &c., &c. The most frightful catastrophe can be produced by simply gradually accumulating the pressure of saturated steam to a strain at which the strength of the boiler yields, nor need that pressure be much above what is ordinarily employed with boilers of this type.

5th. That there is no flashing of the boiler water into steam at the moment of an explosion. On the contrary, with the exception of the small portion of this water vaporized (after the reduction of the pressure owing to the rupture of the boiler) by the contained heat in it between that due to the temperature of the streams of the exploding pressure and of the atmospheric pressure, it remains unchanged, and is thrown around, drenching the objects near it, and scalding whatever it falls upon.

6th. The weakest portion of the boiler braces was in their welds.

7th. The equal stretching in all directions of the boiler-plates between the screw-bolts, due to their bulging under the pressure, was sufficient to permit the slipping out of the bolts without injury to the screw-threads either upon them or in the plates.

8th. That this experiment has conclusively disposed of several theories of steam boiler explosion, replacing vague conjecture and crude hypothesis with exact experimental facts, and, by thus narrowing the field for the search of truth, has made its discovery more probable.

All of which, together with drawings of the boilers experimented with, are respectfully submitted by, Sir,

Your Obedient Servants,

B. F. ISHERWOOD,
E. S. DE LUCE,
SIDNEY ALBERT, } *Chief Engineers U. S. Navy.*

HON. GEORGE M. ROBESON,
Secretary of the Navy.

Chemistry, Physics, Technology, etc.

ON THE MINERAL RESOURCES OF NORTH CAROLINA.

By Fred'k A. Genth.

For a long time past the State of North Carolina has been noted for its great and varied mineral wealth, hence it became the favored field for speculations of every sort, some of these of the wildest character. It is not, therefore, to be wondered at that failure should have met most of those schemes, which contemplated mere stock operations in place of a legitimate development of the mines. However, as an unfortunate consequence of those speculative undertakings, an impression has been cast in our northern cities to the effect that the mineral riches of that state were more imaginary than real. The fallacy and injustice of such a conclusion were fully demonstrated to me twenty years ago, during a residence of nearly two years in the State, and since that time my faith in the mining resources of North Carolina has been strengthened by frequent visits as an expert, during which I have examined most of the gold, silver, copper, lead, zinc and iron mines of the central counties. In addition to those many opportunities of acquiring positive evidence of the mineral wealth of that State, it was my good fortune to spend a great part of last summer in North Carolina in company with Prof. W. C. Kerr, the very able State Geologist, at whose request I visited the principal mineral localities of the State for the purpose of working up the mineralogy for the geological report. My field for examination has been quite extensive, embracing, more or less, about thirty-two Counties of the State.

As one of the results of the geological survey of North Carolina, it may be interesting here to state that it has already contributed to the development of several mining localities, which have invited the attention of northern capitalists; other mining properties are in process of negotiation, and I have no doubt that, when better known, many other mines, which at present are neglected, will command the attention they justly deserve, offering, as they do, inducements for safe and profitable investment.

Although my labors in North Carolina in connection with the geological survey were generally directed to the mineralogy of the State, I have nevertheless made numerous observations, and acquired many facts which may be interesting to the members of the Franklin In-

stitute. I intend giving a brief account of the vast mineral resources of North Carolina, but ere I describe the occurrence of the different ores, it may not be amiss to sketch, in a concise way, the general outline of the geology of that State, without, however, entering into a geological discussion with reference to the position and age of the various rocks, but simply confining myself to their petro-graphical determinations.

Almost the whole State of North Carolina is made up of gneissoid or granitic rocks, alternating with strata of argillites, quartzites and talcose, chloritic and micaceous slates, all more recent rocks, resulting from the destruction of the older.

These are overlaid, in its eastern and south-eastern portion, for a distance of from ninety to one hundred miles from the coast by tertiary and cretaceous deposits, with numerous marl beds, of much local importance for the agricultural development of this portion of the State. Many of these beds contain small quantities of lignite and pyrite, but not in sufficient quantities to be of any commercial value.

The older formations are arranged in nearly parallel bands or belts, which cross the State in a north-east to south-western direction. The tertiary and cretaceons formation rests immediately upon a belt of quartzites and slates bearing N. 25—30° E. with a southeasterly dip, and these are underlaid by granite and gneissoid strata, which border them on the west and form the most eastern granite belt, known as the Raleigh belt, which occupies the greater portions of Warren, Franklin and Wake Counties, with Raleigh as a centre; and extends from there southwestwardly through Richmond County into South Carolina. It consists, to a large extent, of a granular granite, composed principally of orthoclase, greyish white granular quartz, and very little mica, which is frequently biotite. In many places the granite is a real granulite; in others it graduates into gneiss, and, here and there, into hornblendic strata.

The Raleigh belt is overlaid by very extensive beds of slates, argillite, quartzite, etc., with a north-west dip, traversing Granville, Person, Orange, Alamance, Randolph, Moore, Montgomery, Stanley, Anson, Union and the south-east part of Davidson, Cabarrus and Rowan Counties.

To the west of these slates, which have been called *taconic* slates by Emmons, another band of the oldest rocks is again observed. It has been called the Greensboro' and Salisbury granite belt, and occupies

the principal portion of Caswell, Rockingham, Guilford, Forsythe, Davie, Davidson, Rowan, Iredell, Cabarrus, Mecklenburg and the eastern portion of Gaston, Lincoln and Catawba Counties. The granites are often granulites, consisting only of orthoclase and quartz. In many places they became porphyritic, by the dissemination of large orthoclase crystals throughout the mass; again they change to gneiss and micaschist, and frequently, through a gradual admixture of hornblende, they turn to syenite, hornblendic gneiss, hornblende-slates and even diorite. These hornblendic rocks are interlaminated with the granite and gneiss, and their gradual passage from one into the other are evidence of their cotemporary origin. As these hornblendic or dioritic rocks are less readily decomposed, they often form vein-like walls through the other rocks, so-called "trap dykes," and as the result of their partial disintegration, the surface is covered with rounded boulders.

Accumulations of various iron ores, hematites and magnetites, form bands in this belt of gneissoid rocks.

Another band of more recent slates, characterized by several important beds of limestone and magnetic iron, passes from King's Mountain in a northeasterly direction through Gaston, Lincoln and Catawba Counties; here it is interrupted, but it occurs again in Davie, Forsythe, Yadkin and Stokes Counties.

Proceeding in a westerly direction, we again come into the region of the oldest gneissoid and related rocks, very similar to those of the more eastern belts. These make up the bulk of the counties of Wilkes, Caldwell, Alexander, Catawba, Cleveland, Burke, McDowell, Rutherford, Polk and Henderson.

A narrow band of slates borders this granite formation through Surry, Wilkes and the north-western corners of Caldwell, Burke, McDowell, Henderson, and passes through Transylvania County into South Carolina. These slates appear to be connected with those of Stokes county. In this band of slates in several localities there occurs a peculiar quartzite, which, by a minute admixture of mica between the rounded particles of quartz, forms the so-called "flexible sandstone" or itacolumite. The principal localities in which it has been observed are Linville in Burke, Bending Rock Mountain in Wilkes, and Sauratown Mountains in Stokes Counties. In this narrow belt of slates, several valuable limestones and iron ore beds have been discovered.

The last belt of gneissoid or granitic rocks occurs west of these slates.

It is largely made up of gneiss and hornblende slates, with a frequent admixture of garnets and crystals of cyanite. These rocks occur in Alleghany, Ashe and Watauga Counties; they are interrupted, however, in the southern portion of the latter and the northern part of Mitchell county by a narrow strip of slates, which extends into Tennessee; but they then continue through Mitchell, Yancey, the greater portion of Madison, Buncombe, Haywood, Jackson, Macon and Clay Counties, and the southeastern part of Cherokee County. In this belt large veins of granite occur, with massive accumulation of orthoclase and muscovite, associated with garnet, tourmaline, beryl, etc.; also lenticular masses of magnesian rocks with chrome ores, either chloritic slates, etc., or granular chrysolite, which is the parent rock, by the alteration of which, in Pennsylvania, for instance, the serpentines have been produced. The extreme north-western limits of the Counties of Mitchell, Madison, Haywood, Jackson, Macon and the greater portion of Cherokee, are again occupied by slates, frequently inclosing beds of marble and granular dolomite interlaminated with beautiful talcslates or micaceous slates, containing large crystals of staurolite, garnet, etc.

I have yet to mention as a very important formation the "triassic," which occupies a portion of the central counties of North Carolina. Resting upon Emmon's so-called taconic slates, narrow bands of shales and sandstones pass through Granville, the eastern edge of Orange and the western of Wake County, which in Chatham and Moore Counties widen and contain several valuable beds of coal; the formation continues through the south-east edge of Montgomery, thence through Anson County into South Carolina. The dip of these strata is south-east, and they form the south-eastern portion of the triassic formation, the central portion of which has been removed by erosion, whilst the north-west portion, with a north-westerly dip and resting directly upon gneissoid and granitic rocks, appears again in Rockingham and Stokes Counties, where it shows sandstones, shales and numerous outcrops of coal beds.

The gneissoid or granitic strata, as well as the slate formation, are frequently intersected by metallic deposits, either in veins and associated with quartz as a vein rock, or in ore beds, interlaminated with the strata, and forming a portion of the formation.

I will now proceed to the consideration of the occurrence of the different metals and other valuable minerals:

Gold. According to the earliest records the first piece of gold

found in North Carolina was picked up in 1799, in a little branch at the Reid plantation, Cabarrus County. It weighed between three and four lbs., and was kept several years without its real character being suspected ; subsequently it was sold to a jeweller in Fayetteville for $3.50. When its true character became known, search was made for more, and fourteen lumps, weighing in the aggregate 153 lbs. troy, were obtained at the same locality.

The gold veins and gravel deposits were afterwards discovered ; and for a considerable time gold operations were conducted in many localities on a comparatively large scale. The discoveries of gold in California, where a far richer harvest was promised, led to the abandonment of many of those enterprises ; other causes have also influenced in the same direction, as, for example, the difficulties connected with deep vein mining, and the impossibility of extracting the gold by the imperfect and slow machinery then principally in use, the Chilean Mill and Arastra, etc., from heavy ores like pyrite, &c., which nature has not already decomposed. With the exception of minute quantities of telluride, in the *very rare* mineral nagyagite, at the King's mountain mine, gold in North Carolina is always found in the metallic state. It is rarely quite pure, but generally alloyed with more or less silver. It occurs in crystals or crystalline masses, in thin plates or laminæ, between the foliation of the slates or through associated minerals, such as quartz, pyrite, galenite, zinc-blende, etc., in such a fine state of division that it is generally invisible to the eye.

It has been observed in four different geological positions :

1st. It is met with in the *mass* of the gneissoid, granitic and hornblendic rocks.

2d. In quartz veins, often associated with pyrite, chalcopyrite, galenite, tetradymite and other minerals.

3d. In ore beds, cotemporary with the strata of rocks in which they are found, as in chloritic and talcose slates, argillites, quartzites, etc.

4th. Loosely in the soil and decomposed rocks, especially in gravel deposits, resulting from the destruction of the above first three formations. One of the most remarkable features peculiar to the rocks of the Southern States is their rapid disintegration.

The débris from these rocks forming the soil or ferruginous clay, remains in situ. This disintegration is frequently observed to a depth of over one hundred feet. Many of the railroad cuts show beautiful sections, and the study of these exhibits some highly interesting

features, which I shall mention, as they are of the greatest importance to a full comprehension of the subject.

In many places cuts may be seen which appear to have been made in a uniform mass of clay, which, in general, is ferruginous; on close observation, however, it is easy to recognize that the *apparently* uniform clay stratum belongs to two distinct formations.

Immediately below the soil, which may be covered by vegetation, the ferruginous clay will be seen to contain, here and there, small fragments of quartz in angular pieces, with the edges more or less rubbed off, disconnected and not occurring in regular seams or veins; the number of those quartz pebbles gradually increases at a greater depth, until they form a regular stratum of gravel.

Some of those gravel beds are hardly perceptible; others vary from a few inches to over thirty feet in thickness.

When the great denudation took place, these fragments of quartz deposited themselves upon the *then* unaltered bed rock—the granite, gneiss, micaschist, slate, etc.; but after this period the disintegration of the rock continued, and it is natural that the same kind of clay should have resulted from the same parent rock.

Therefore we find, just below this gravel bed, ferruginous clay as above, but a closer investigation shows a great difference and especially two striking facts: in the first place the stratification can be observed and followed to the underlying, undecomposed rocks, and secondly, the quartz, which is found in the same, occurs not in loose angular pieces, but in regular seams or veins, in their original position.

In some of the auriferous regions of North Carolina, such quartz veins are very numerous; in others, they are less frequently met with.

Most of them are exceedingly small, varying in width from the thickness of a knife's blade to a few inches, and often extending in depth but a few feet; some bulge out and form nests or pockets in the rocks, while others again are of enormous size, and are known to exist as deep as they have been developed, which, in a few rare instances, is down to 200—300 feet.

Many of these quartz veins are in reality beds, as they coincide in strike and dip with the stratification, whilst an equally great number run in every conceivable direction, and dip just as irregularly.

The greater portion of these quartz veins contain *no* gold, or only such a small quantity that they could not be profitably worked, especially the large veins of vitreous and milky quartz.

Many of the small veins, principally those which contain granular or saccharoidal quartz, are rich in gold.

Some of the large veins, especially those containing much cellular quartz, have frequently been found to be the most productive. This cellular quartz results from the decomposition of pyrite, which once occupied the now empty spaces; leaving them either occasionally quite free from iron, or more generally rusty and more or less filled with limonite. These, the so-called brown gold ores, are the best and most easily worked. At a greater depth of the veins, where the pyrite is not decomposed, the gold is so much mixed with heavy sulphurous ores that, with the present system of operations, it cannot be extracted with profit; in many cases the gold disappears entirely.

Most of these gold veins in North Carolina were abandoned, when the iron and copper pyrites increased too largely, and before they had been wrought deep enough to contain copper ores in paying quantities.

The gold in these mines is not evenly distributed through the mass of the gangue; the veins often contain entirely barren portions alternating with rich ones, the latter called shoots of ore or chimneys.

Such shoots are in reality veins inside of a vein, and are frequently quite regular in their dip; the ores at the foot wall are generally richer than those at the hanging wall.

Many gold mines of this description have formerly been worked, and many of them undoubtedly are still of great value.

In Guilford County there were the McCulloh and Fisher Hill mines; in Cabarrus County, the Phœnix, Vanderburgh, Cullen, Pioneer Mills mines; in Mecklenburg County, the Capps, McGinn, Rudesill mines; and numerous others. At present, almost every one of them are unworked; some explorations are carried on in Cabarrus County, and in Mecklenburg County the McGinn and the Wilson mines are the only ones in operation, and that on a small scale only.

At the McGinn mine they have a 5-stamp battery and amalgamated copper plates, also roasting ovens to decompose the sulphides; at the Wilson mine there is a 10-stamp battery with amalgamated copper plates, all after California patterns.

Many of the quartz veins in the slates, differing in strike and dip from the inclosing slate, carry gold, especially those which contain cellular and cavernous quartz, associated with limonite, hematite, siderite, pyrite, chalcopyrite, etc.

Some of them are highly promising, as, for instance, those of the

Conrad Hill mine, in Davidson County; but, unfortunately, not a single vein has been sufficiently developed in depth to form a just appreciation of its value.

The gold deposits, which are cotemporary with the slates themselves, are of far greater importance than the true gold veins.

The talcose, chloritic, micaceous or arenaceous slates in which they occur, contain portions which are more or less charged with gold. The gold in these slate beds, like the slates themselves, is derived from the destruction of the older rocks, and has been deposited simultaneously.

The width of these auriferous beds varies from a few inches to from 60 to 70 feet.

The gold in them is often found without any admixture, and the auriferous strata shows no line of demarcation, and cannot be distinguished from the barren layers; but, generally, and subsequently to its deposition, it has been acted upon by chemical agencies, dissolved and precipitated again, and has assumed a crystalline structure; it has accumulated in strings which sometimes form lenticular and more highly auriferous masses in the beds, and is associated with crystalline quartz, pyrite, chalcopyrite, galenite, blende, mispickel, etc.

These are often parallel with the slates, and so close together that they can be worked by the same operation, especially where the slates between are also auriferous.

The Steele mine, in Montgomery County, and the Stewart mine, in Union County, are examples of this occurrence.

These gold mines have proved to be the only reliable ones in depth, and, if they are found to be rich enough for working, they can be depended upon for the future.

To this class belong the mines at Gold Hill, in Rowan County, which have already produced not less than $2,000,000, and have reached a depth of 750 feet. Although this appears to be a very large production, I do not hesitate to say that perhaps four-fifths of all the gold in the ore, which is a talco-micaceous or chloritic slate, intermixed with pyrite, magnetite, and a little quartz, has been lost in the tailings, on account of the very imperfect process used for the extraction of the same.

The King's Mountain mine, of Gaston County, also belongs to this class. The gold is, to a great extent, contained in a quartzose limestone, and is associated with very small quantities of pyrite, gale-

nite, chalcopyrite, but also with the very rare tellurides of lead, altaite, and with nagyagite, a telluride of gold and lead.

In some places this ore bed is over thirty feet in thickness, and has been worked to a depth of 200 feet, but longitudinally only to a very small extent, not over 250 feet.

This mine is also said to have produced over $1,000,000. The machinery used for the reduction of the ores are a 20-stamp battery with amalgamated copper plates, etc.

There are at present no other mines belonging to this class in operation, but there is no doubt that Montgomery, Union, Stanley, Rowan, Davidson, Randolph, Gaston and Cherokee Counties have many localities, where profitable and successful mining operations might be carried on.

In gold mining operations, the deposits which result from the disintegration of the rocks, and subsequent denudation, are undoubtedly of the greatest importance; there the gold which was contained in the rocks and in the small auriferous veins (which have been broken up into fragments) has been concentrated by nature, and in many places has been deposited, with the remnants of the veins, in the gravel beds, which I have already mentioned.

Those gravel beds occur to a greater or less extent throughout the whole gold region; the oldest gneissoid rocks as well as the slate formation contain them.

The quartz in general is not water-worn, only the sharp edges are rounded. Many pieces still present the shape and thickness of the veins whence they came.

The most extensive gravel deposits exist in the South Mountains, on the headwaters of the first and second Broad River, Muddy Creek and Silver Creek, in the Counties of Rutherford, McDowell, Burke, Caldwell, also in Polk, and Cleveland; embracing an area of over 200 square miles.

They appear to cover the greater part of the land, rise often to a considerable height on the slope of the hills, but are naturally more concentrated in the bottoms and flat lands. The gravel beds in this region vary in thickness from a few inches to thirty feet, and are covered with soil and clay, which is also more or less auriferous, although much poorer than the gravel beds below.

These deposits have been worked since about 1830, and before gold was known in California many thousands of hands were at work digging and washing in a rude way, yet many millions of dollars were

produced without the help of any complicated machinery, and without the knowledge of a proper use of water.

Since that time very little has been done; in some instances the old gravel was worked over again, and has made fair returns to the adventurers.

Very large tracts of land, containing extensive and valuable deposits, have never been touched, and, by the introduction of the Californian hydraulic system of operations, a safe and very profitable business could be carried on.

The gold is rarely found in nuggets; generally as fine dust and in small grains. Its fineness averages about 825 thousands. It is associated with numerous interesting minerals, such as platinum, diamond, zircon, xenotime, monazite, and many others.

Experiments with vein-mining in this region have not proved successful; the rich veins are too narrow in width, and of too limited extent in depth, and the large veins do not contain enough gold to be advantageously worked.

A small region of valuable gravel beds exists in the gneissoid rock and micaceous slate of Franklin and Nash Counties, in the eastern part of the State. It has been most extensively prospected at the Portis mine, where it is very rich, and has been worked since about 50 years, having produced, it is said, over $1,000,000.

The productive gravel is here the result of the disintegration of numerous small granular or sugary quartz veins, and very fine specimens of gold in such quartz are frequently met with.

The fineness of the Portis mine gold was generally about 985 thousands.

There are enormous gravel piles at the mine—the remnants of former operations.

Some very important but expensive experiments have been made at this mine.

Machinery was here erected for crushing and amalgamating the gravel, which, being part of gold veins, was thought could be profitably worked for gold.

The result was precisely what my own examination of the place convinced me it should have been—*a failure;* because, whilst the gravel may contain some very rich specimens, the whole bulk is too poor to be worked with profit. This is accounted for from the fact, which I have already intimated, that the gold in the gravel deposits, principally, is the *loose* gold, which had existed in the rocks and be-

tween their laminæ, or that from the *small* quartz veins, whilst the large veins are mostly *barren*. In a region which contains many small veins, the gravel deposits are generally valuable, even if the bulk of the beds has been made up from the destruction of large ones.

There are several highly important gravel deposits in Montgomery County, in the slate formation, some of which have produced a large amount of gold; the gold is mostly crystalline, in flat pieces, often covered with octahedral crystals, and in large nuggets; very little fine-grained gold has been found.

The best known deposit, which has produced large returns, but which is still, so to say, barely touched, is the so-called Christian mine.

The Swift Creek mine, about seven miles distant, produces gold of similar appearance.

West of the Blue Ridge several gravel deposits have been worked, to a greater or lesser extent, in Cherokee and Jackson Counties, also at Howard's Creek, in Watauga, and on the French Broad and New Rivers.

Throughout the whole gold region, every stream, branch and rivulet contains gold; and, as the washing of these is the most convenient way to obtain the precious metal on a small scale, there is hardly one which is not more or less worked, many of them up to their source.

Platinum. Only a few grains have been found in North Carolina, associated with gold in Rutherford and Burke Counties; and there is no prospect that it ever will be found in large quantities.

Silver, Lead, Zinc. I shall consider those three metals under one head, as they are always associated.

Silver is a rare metal in North Carolina. With the exception of the silver alloyed with gold, varying from 1 or 2 to about 20 per ct., in the gold from veins and gravel deposits of the granitic and gneissoid rocks, very little silver has been found in the veins of these strata.

The only localities which came under my notice were at the Baker mine, in Caldwell, and at Scott's Hill, in Burke County. There it occurs but rarely, in veins of auriferous quartz. At the latter place it is only observed after burning the ore, and a little fragment which I have seen makes me feel confident that it is present as cerargyrite, or chloride of silver.

Small quantities of argentiferous galenite and pyromorphite are associated with it.

Native silver has been observed with chalcocite or copper glauce at Gap Creek mine, in Wilkes County, and at the Asbury vein in Gaston County.

The only real silver mines of North Carolina are ore beds of zinc blende, mixed with galenite, in the argillaceous and talcose slates. The type of these is the old Washington mine, now Silver Hill, in Davidson County, which was discovered in 1838. Near the surface it formed a bed of carbonate of lead, having in many places films and plates of metallic silver disseminated through the mass of the ore. These ores were easily reduced, and produced handsome returns to the owners. This was, however, but of short duration. The undecomposed ores, which were a very fine-grained mixture of brown zinc-blende and argentiferous galenite, were soon reached, and presented great difficulties in the extraction of the precious metals.

When I was at the mine, about 22 years ago, an analysis of an average sample of between 2000 — 3000 tons of ore gave me about 45 per ct. of zinc, 21 per ct. of lead, about 8 ounces of silver per ton, with minute quantities of copper and gold. If the Philadelphia owners had abided by my advice, viz., to work the ores for zinc, and extract silver, copper and lead from the residues, they would probably still be in possession of this valuable mine.

The ore bed is large, and in one place has had a thickness of about 60 feet.

Occasionally it contains very rich spots, with native silver in lumps and filiform masses, or disseminated through the ore with argentite or highly argentiferous galenite; and besides these minerals this mine has furnished the most magnificent cabinet specimens of cerussite, pyromorphite, etc.

The mine is now 650 feet deep, and the ore is greatly mixed with slate. The purer masses are kept separate; the slaty ore is crushed and separated by buddles, etc., and the buddled ore is roasted and shipped to New York for the manufacture of the so-called Bartletts' white lead. The production of this mine is now about 400 — 500 tons per month.

Very similar ore is found about six miles north-east of Silver Hill. The vein has not been developed, and the work done at Silver Valley has not been productive.

The Hoover mine, about six miles from Silver Hill, contains gale-

nite, in a more coarsely crystalline variety, in a calcareous veinstone, and the Boss mine, two miles distant, has furnished handsome cabinet specimens of galenite in quartz.

The McMakin mine, about $1\frac{1}{2}$ mile south-east from Gold Hill, is a very interesting one; the principal vein is a large vein of zinc-blende in talcose and argillaceous slates; it contains native silver, argentite, argentiferous galenite, and highly argentiferous tetrahedrite. The latter contains, according to my analysis, 10·53 per ct. of silver, and an average sample of ore of a 5′ vein, at 80 feet depth, which was sent to me about 11 years ago, yielded 246 ounces of silver per ton, worth about $334. The mine is not worked, but looks favorable enough to deserve fresh attention.

The Troutman mine, also in the neighborhood of Gold Hill, and one mile south-east of it, has been opened as a gold mine. It consisted of porous quartz, and yielded near the surface very rich ores, worth $50 per bushel; at the depth of 100 feet, where the sulphides are undecomposed, the ores yielded only $1, and contained a string of ash grey zinc-blende with pyrite, from 2 to 6 inches in width, which had increased to 18 inches when abandoned at a depth of 160 feet. These ores are well worthy of a fuller investigation, as they may be rich in gold.

I have already mentioned, when speaking of gold, the beds and veins of gold ore in Union and Montgomery Counties, as being frequently associated with zinc-blende. The string veins of the Steele mine principally consist of these and galenite.

At the Long (or Monroe) mine, in Union County, the quartz veins in the slates are richly charged with argentiferous galenite; but the veins have not been sufficiently explored to know whether it will increase in depth.

At the Lemmond (Marion) mine, a very remarkable vein or bed has been worked; it is irregular in size, sometimes widening out from a few inches to six feet. It consists of quartz, richly charged with brown zinc-blende and galenite, with small quantities of arsenopyrite, chalcopyrite, often intermixed with grains of electrum, a highly argentiferous variety of gold. Both the galenite and the zinc-blende are very rich. I have examined a *pure* specimen of galenite which did not show any admixture of *free* gold to the eye, but which yielded at the rate of nearly 30 oz. of gold and $86\frac{1}{2}$ oz. of silver to the ton; and pure brown zinc-blende gave me about 32 oz. of silver and gold, nearly half of which was gold. This vein appears to have

a considerable longitudinal extension, and passes into the Steward mine property, formerly owned in this city.

At the latter mine, and at various other localities in this region, similar ores have been found, but the war has stopped all operations, and it will require capital and skill to develop this highly important mining district.

Galenite and zinc blende occur at several other mines, associated with gold ores, as at the Kings mountain, the Cansler and Shuford, and the Long Creek mines in Gaston county, etc. At Cedar Cove, McDowell county, in the limestones of the so-called taconic slates, at the Dobson mine, there is found an accumulation of yellow and yellowish brown zinc-blende mixed with lime. I have not, however, seen anything from there which looks encouraging.

Galenite and zinc-blende is associated with the gold ores at Murphy, Cherokee county. Highly argentiferous galenite occurs at several localities on Beech mountain, Watauga; argentiferous and auriferous galenite have been discovered at Flint Knob in Wilkes County, and I have seen specimens of it from Marshall, Madison County, Clayton, Johnson County, and Elkin Creek, Surry County, and also in several of the copper mines throughout the State, but I have no knowledge of any deposit of sufficient magnitude to be worked advantageously.

Tin.—No tin ore has been found in North Carolina as yet. Traces of this metal have been found in the tungstates of Cabarrus County, and in a micaceous slate in Gaston County, associated with garnet and columnar topaz (pycnite).

ON THE ABSORPTION OF GASES BY WATER, AND ON THE ORGANIC MATTERS CONTAINED THEREIN.

By G. W. Baird, U. S. N.

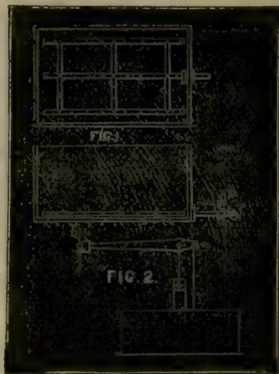
Our attention was called to this subject a few years ago by some attempts made to ærate water on board ship. We had been suffering from the flat oleaginous and insipid taste of the freshly distilled water, and in our endeavors to render it potable within a reasonable length of time, it was found that the subject was one of no small importance, and attended with many difficulties.

By exposure to the air from four to five days the water became sweet and potable, and by exposure to the foul gases of the bilge it also became potable and sharp.

By delivering the water warm into the ship tanks it became potable much sooner than when delivered cold, though it was a well established fact that gases are less soluble in warm than in cold liquid. The water as delivered appeared as clear as crystal, yet there was always a mass of filth deposited on the bottom and sides of the tank after the lapse of a few months.

ABSORPTION OF AIR.

By subsequent investigations it has been proven that the "sharpness" of the water is due entirely to the amount of gas held in solution, and the oleaginous and insipid taste are due to the essential oils and organic matters brought over by the steam.



Our first attempt to purify the water was by forcing a blast of cold air through perforated pipes, situated in the bottom of a tank of known capacity, and a set of experiments conducted but with very unatisfactory results. The bubbles of air rise very rapidly to the surface of the water and in right lines, without seeming to agitate the water at all. Experiments of ten hours durations were made, with the temperatures varying from 75° to 120° Fahr., and the water compressed in a small cylinder (Fig. 2) the measurements being made on the scale (*b*), and each set compared with the standard tension. The standard tension was obtained by subjecting water of fifteen days exposure to the air to a given pressure in the same instrument, and the deflection of the lever registered at one (1). The others were, consequently, in fractions of this unit.

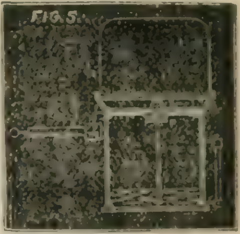
Table A is the result of this set of experiments.

TABLE A.

By a blast of air directed through the water.

Temperature of water, Fahr.	75	80	85	90	95	100	105	110	115	120
Temperature of air.	68·43	68·104	67·98	68·112	68·181	67·875	68·17	68·645	68·	68·[illegible]
Compression of water compar'd with that of saturated water.	0·5625	0·4820	0·470	0·375	0.315	0·2812	0·2105	0·190	0·1555	0·0927

From these experiments it is evident that the nearer the temperatures of the air and water approach each other, the more readily they combine. It is equally evident that, with such apparatus, it is impossible to retain them at the same temperature long enough to determine the time required for saturation.



A fountain (fig. 5) was then constructed which injected the water in a spray, the pressure inside being kept up by means of a pump. Much time was consumed in making a proper nozzle, and it was demonstrated at the very first trial that the firmer the spray be divided the more rapid would be the absorption of gas.

Fig. 3 represents an enlarged view of the nozzle adopted, and one with which the following experiments were made: The water passes through the nozzle *a*, inducing a current of air or other gas through the openings *bb'*, issuing through the opening *c* in a beautiful spray, approaching, in fineness, a mist.

The saturated water was removed from the fountain by being displaced by mercury, it was then collected in a florence flask, the gases expelled by heat and collected in the metric glass, Fig. 4.

The gases were conveyed through the pipe *a* into the glass metric tube *b*, the weight of which was balanced by the cord running over the pulley *p* to the conical pulley *c*, and to the weight *w*. The object of this system of weights and pulleys was to maintain a pressure inside the tube, equal always to that of the external atmosphere, to eliminate, as far as possible, the errors that creep into calculations from experiments made under constantly varying pressures and temperatures.

The Absorption of Air was completed after three hours and a half, the water giving the same compression as water of fifteen days exposure. Experiments were then made with varying temperatures,

the time required to dissolve the gases increasing almost directly with the temperatures. Our attention was then directed to the

ABSORPTION OF OTHER GASES.

The glass shade over the fountain (fig. 5) was filled with the gas under investigation, the temperature and pressure being the same as that of the external atmosphere at the time the gases were withdrawn for measurement.

The same metric tube was used as before.

VOLUMES OF GASES DISSOLVED IN THE UNIT VOLUME OF WATER.

Carbonic Acid	Oxygen	Nitrogen	Sulphuretted Hydrogen	Carbonic Oxide	Marsh Gas	Nitrous Oxide
1·57	0·04692	·0255	3·1435	0·0327	·0543	1·3052

The above table gives the amount of gases soluble in pure water. Water, after dissolving four hundred times its volume of ammoniacal gas, seizes its normal volume of any other gas and absorbs it as readily as if not already impregnated. But the quantity of oxygen necessary to oxidize organic matter in water, is much greater when other gases are present.

RAIN WATER.

The quantity of gases dissolved in rain water was found, by Peligot, to be twenty-five cubic centimetres per litre, or 6·10699 cubic inches per 61·74 cubic inches = 2·47 per cent. of gas. The ratio of absorbed oxygen to nitrogen is greater by volume than in air, on account of the greater solubility of oxygen in water.

Peligot has given the following analysis, by measure :

Atmosphere.		Gases in Rain Water.	
Oxygen .	20·81	Oxygen	31·20
Nitrogen .	79·21	Nitrogen	66·40
		Carbonic anhydride	2·40
	100·02		100·00

Rain water also contains nitric acid and ammonia, and sometimes nitrous acid.

Sulphurous acid is often found in the rain falling in or near manufacturing towns.

All liquids and solids absorb or condense on their surfaces, and in their pores, certain definite quantities of every gaseous body with which

they are placed in contact. The quantity of gases thus absorbed depends on the properties, both physical and chemical, of the bodies brought together, and on the temperature and pressure under which the absorption takes place. Charcoal is a powerful absorbant of oxygen, taking it freely from the atmosphere and liberating nearly all of the nitrogen, for which it has but little affinity.

ON THE ORGANIC MATTER CONTAINED IN WATER.

Surgeon Woods, U. S. N., of the Mare Island Hospital, kindly furnished us with five specimens of water, distilled at the Hospital, as follows:

(1). Distilled, ærated and filtered through animal charcoal.

(2). Distilled, ærated but not filtered.

(3). Distilled, but neither ærated nor filtered.

(4). Distilled, filtered but not ærated.

(5). Salt water, used in the still.

The ærating apparatus was an air-injector, placed in and forming part of the steam pipe, connecting the boiler and condenser.

The filterer was a double return column, the water passing through both, but its velocity, depending on the difference of heights of water in the two columns, was very slow. By such a filterer water is much more effectively deprived of any solid matter held in suspension than by any other form.

The salt water, which was the first taken in consideration, is essentially a chlorinated alkaline mineral water. The saline contents were chiefly sodic, magnesic, potassic and calcic chlorides and sulphates. The organic constituents consisted of a number of very beautiful spores, which gradually develop and produce a very beautiful flower. These flowers are rich in color and luxurious in the quantity, and arrangement of their tints.

We are indebted to Dr. Burgess, of San Francisco, for the use of an admirable microscope of very high power and elegant construction, and for the assistance that gentleman afforded us in our microscopic investigations.

Each specimen was subjected to a careful examination under a quarter inch object glass, before and after exposure to the light, without any discovery in any of those specimens that had been either filtered or ærated. It is easily understood how spores may be removed by filtration, but it is difficult to believe that they could be completely oxidized by any process of æration

Seven different specimens, treated with pure chrystalline sugar, gelatin, creatin and gum arabic, developed no germs; while in those specimens which were unfiltered and unærated, a single day was sufficient to develop germs, when exposed to the light.

Having failed to develop either spores or animalculæ in the ærated or filtered water, our attention was given entirely to specimens Nos. 3 and 5, namely, the unfiltered and unærated distilled water, and the salt water from which specimen No. 3 was distilled.

After twenty-four hours exposure to light, (in a closed phial) No. 3 showed a small number of germs, scattered about, and of very different sizes and colors.

By treating with crystalline sugar they collected together like bunches of grapes, their colors gradually assuming the same shade. By further exposure to the light they developed into spores and gradually into beautiful flowers, exactly the same as those in the mother salt water, except that the tissue was more delicate and transparent. Finally the same stalks developed, put forth into tiny branches, produced the same flowers as in the sea water, but retained the delicate transparancy which could not be found in any of the salt water tissue. Day after day a drop of each was examined under the microscope, and while the total quantity of matter in the salt water seemed to remain constant, that in the distilled specimen increased rapidly, until, after a few weeks, shreds and clusters of it could be seen with the naked eye in every part of the phial. A few grains of potassic permanganate was introduced into the water in this state, which rapidly oxidized the tissue and precipitated quantities of putrid fungi, which, when received under a quarter-inch object-glass, presented a jelly-like appearance.

After a few days of additional exposure to the sun, spores again made their appearance, developed, ripened and produced the same flower as before, but this time darker and more dense even than those produced by the salt water.

The following is copied from the British *Chemical Journal*, Vol. XXI, being a lecture by Dr. Frankland, F. R. S., to the Association.

ON THE DETERMINATION OF THE AMOUNT OF OXYGEN NECESSARY TO OXIDIZE THE ORGANIC MATTER IN WATER.

"By the addition of known weights of different organic substances to equal volumes of pure distilled water, the latter was artificially

contaminated with a known proportion of each kind of organic matter. Every sample of water so contaminated was made to contain three (3) parts of organic matter in 100,000. The amount of oxygen which this organic matter abstracted from potassic-permanganate was first carefully ascertained, and then the actual amount of organic matter in the water was calculated on the assumption that eight (8) parts by weight of organic matter consumed one (1) part by weight of the permanganate.

"The same test was also applied to another sample of distilled water, from which all organic matter was carefully excluded, but to each 100,000 parts of which three parts of sodic nitrate were added. The importance of this experiment will be evident when it is remembered how frequently nitrates are present in potable waters. The amount of oxygen consumed was determined for two different times, viz.: First, for a period, at the end of which the acidulated and contaminated water remained tainted with the permanganate for ten (10) minutes after the addition of the latter, and secondly, for a period of six hours, during the whole of which time the permanganate was present in excess. The results are contained in the following table, where they are compared with the known amounts of organic matter present, and the known amount of oxygen which that organic matter would require for its complete oxidation:

1	2	3	4	5	6	7
Name of substance, three parts of which were contained in 100 000 parts of water.	Oxygen absorbed in ten minutes	Oxygen absorbed in six hours.	Oxygen required to oxidize organic matter in water (calculated)	Amount of organic matter present (calculated from column 2.)	Amount of organic matter present (calculated from column 3.)	Amoun't of organic matter actually present
Gum arabic	0·0102	0·0350	3·55	0·082	0·280	3·
Sugar cane	·0064	·0152	3·37	·051	·111	3·
Starch	·0142	·0302	3·55	·114	·241	3.
Alcohol	0·0093	·0164	6·26	·074	·141	3·
Creatin	·0080	·0172	6·59	·064	·138	3·
Gelatin	0·0792	·0836	6·76	·634	1·169	3·
Urea	·0092	·0119	6·40	·071	·095	3·
Hippuric aric	·0328	·0600	5·90	·262	·480	3·
Oxalic acid (crystalized)	·3747	.375	0·38	2·998	3·000	3·
Sodic acid	·691	·6913	0·00	5·521	[illegible]	0

From this table it is seen that of the nine kinds of organic material operated upon, only one was completely oxidized by potassic permanganate, even after the lapse of six hours; whilst it will be remarked that urea, hippuric acid and creatin—three organic sub-

stances likely be to present in water recently contaminated with sewage—suffer an oxidation which only reaches $\frac{1}{50}$ of complete oxidation; whilst if the attempt be made to calculate the amount of these substances present in the water, from the quantity of oxygen so absorbed, instead of finding three (3) parts in each 100,000 we obtain only 0·138 part of creatin, 0·095 part of urea and 0·480 of hippuric acid."

THEORETICAL VIEWS.

From the experiments of Dr. Frankland, and those made by ourselves, there is but little doubt that the unoxidized condition of the organic matter after the specified period of duration, was due to imperfect diffusion; the degree of the oxidation of most of the substances depending upon the time they remained in contact with the permanganate.

But in the sample of ærated water (No. 1) though it had not been filtered, there could not be found a trace of any organic matter. It is popularly believed that the organic matter brought over with the steam is thoroughly oxidized by its contact with the atmospheric air, which is mixed with the steam and has the same temperature. By such means there is probably a most perfect diffusion of all the gases of the atmosphere with the steam and with each other, and being assisted by temperature, little or nothing escapes oxidation.

Bibliographical Notices.

Half Hours with Modern Scientists. Charles C. Chatfield & Co., New Haven. 1871.

The publishers have very judiciously issued, in book form, the first five numbers of their "University Scientific Series," and will doubtless be amply repaid for their experiment. The volume contains lectures and essays from Huxley, Barker, Cope and Tyndall.

The matter of the discourses needs no comment. They have already received the heartiest tribute of praise which is their due. They have inaugurated almost a new era in the influence they have exerted upon popular thought. They have served the great purpose of breaking down the barrier of exclusiveness with which men of science had hedged themselves about. They have presented the aspirations and strivings of physical investigators in terms free from technicality and

characterized by a diction forcible and elegant, and by clothing the magnificent results achieved by modern thinkers with all the charms of romance, have awakened an interest and sympathy in the public mind, which, as it tends towards the universal diffusion of the truths and methods of science, and an intelligent appreciation of her claims for support and encouragement, affords the happiest auguries for the future.

A Practical Guide for the manufacture of Metallic Alloys, comprising their Chemical and Physical Properties, with their Preparations, Composition and Uses. Translated from the French of A. Geuttier by A. A. Fesquet. Philadelphia, Henry Carey Baird, Industrial Publisher. 1872.

The work above named contains in brief space a compilation of nearly everything that is known concerning the chemical and physical properties of alloys, adapted to the most varied industrial purposes. Besides this general matter, quite an amount of special information of just that kind which alone is available and serviceable to the practical metallurgist is given, concerning the composition, mode of preparation and uses of a great number of alloys. The numerous critical observations of the author upon the relative merits of various compositions for special purposes in the arts, founded partly upon his own observations and experimental researches—for which his position would afford him ample opportunity—and partly upon the practical experience of others, will be found to be of great value to experimenters in this branch of technology.

The Civil Engineer's Pocket Book. By John C. Trautwine. Claxton, Remsen & Haffelfinger, 819 and 821 Market street, Philadelphia.

We have here a volume which simplifies the abtrusities of mechanical science, and gives rules and examples at once "susceptible of complete and satisfactory explanation to any person who *really* possesses only elementary knowledge of arithmetic and natural philosophy." Let every mechanic rejoice that we have at last a book which presents the knowledge he wants in *intelligible language.*

It contains a treatise on Mensuration amply illustrated, a marvel of clearness and compactness, and includes a table of spherical surfaces and solidities from $\frac{1}{64}$ of an inch up to 100 inches diameter, advancing with no greater fraction than one-eighth of an inch. Synopses of

Arithmetic, Geometry and plane Trigonometry, extended tables of squares and cubes and corresponding roots of numbers from ·1 to 1000 and roots to 10,000.

Weights and measures with numerous decimal equivalents, translating at once the units of any measure into equal values of every other.

Tables and Rules relating to surveying, with description and manipulation of field engineering instruments.

To the very important subject of the "strength of materials," 69 pages are devoted, and in this liberal allotment of space we find full and clear expositions of Strength and Strain, disposition of materials, Joints and method of Joining, and in fact the essential bearings to every day practice of this department of engineering. We have not seen together in any work so much matter in the shape of rules and formulæ, which can be so readily understood and applied. This has also the additional advantage of presenting the later experiments and deductions.

Sixty-six pages are given to trusses and trestles, with ample illustrations, elucidations and calculations. Forty-six pages to stone work, including foundations, retaining walls and stone bridges. Two hundred and fifty-eight pages principally to the weights of metals and products, strengths of chains and ropes, specific gravity, rails and joints, turnouts and turntables and apparatus therefor, railroads and earthwork, the mechanics of force in rigid bodies—an admirable chapter—mortar, brick, cement and concrete, hydraulics and hydrostatics, dams, suspension bridges, friction, traction and animal power, and after these a glossary of terms used in the arts; finally a very clear and complete index, making in all 645 pages.

Next in importance to having the thing wanted, is the means of finding it promptly, and the index to this volume is one of the best. This, like the index of the "Ordinance Manual," has the leading subject set in bolder type and strikes the eye at once.

In this feature, so often slighted, in the typographical execution and make up of the work, particularly in the abundance of large and eminently useful fact, compressed into smallest space, Mr. Trautwine's Engineers Pocket Book must take highest rank.

J. H. C.

Obituary.—Adolph Strecker died on the 7th of November at Wurzburg in Bavaria, after a short illness. His fame as a Chemist is not so widely known in America as in Europe, though all who are familiar with the literature of chemistry have heard of him.

Prof. Strecker was a native of Darmstadt, whence Liebig, Kekulé and so many of the celebrated scientists of Germany came. At an early age he entered the University at Giessen, devoting himself to mathematics, but afterwards took up the study of chemistry with Liebig. He gained his degree of Dr. in Philosophy, and then was appointed private assistant to Liebig and afterwards *Privat Docent.* Here he was associated with Fresenius, Merck, Fleitmann, Wetherill and many others whose reputations are so great as workers in science. Receiving a call to Christiana as Professor, he left Germany for a number of years, but was busily engaged in work which aided the development of the newer chemistry. From Christiana he went to Tübingen in Württemberg, where he remained nearly nine years, during most of which time he directed the *Jahresbericht* and *Liebig's* Journal, aided in the compilation of the "*Handwörterbuch der Chemie,*" and published seven or eight editions of his Manuals of Organic and Inorganic Chemistry. These latter are text books to the elementary lectures in all the German Universities, and though not translated into English, are used in Russia and France. Prof. Strecker received last year two calls, one to Cincinnati with a salary of $5,000, and another to Wurzburg, to succeed Prof. Sherer, who had died there. This latter appointment he accepted, and removed thither, believing that he could work more industriously. Some years ago, whilst experimenting on Prof. Crooke's new metal, Thallium, Prof. Strecker was injured by noxious vapors, and suffered great privations and agony, and finally endured an operation, but without any permanent relief. Doubtless his early demise is owing to the disease contracted by this misfortune, for he died of asthma, and the writer has often seen him lecturing with his throat and head tied up, so that only one eye was visible, inflammation of the acutest kind afterwards overcoming him for days. Unassuming but dignified, energetic and unceasing in his labors, Prof. Strecker's short career has been crowded with distinction. His labors are the means of instruction to thousands, and the writer having worked under his supervision knows how sadly his loss will be felt by all students in chemistry.

Philadelphia, Nov. 25, 1871. F. H. R.

Franklin Institute.

Proceedings of the Stated Meeting, Sept. 20th, 1871.

The meeting was called to order by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers and reported that, at their stated meeting held September 13th, donations to the library were received from

The Royal Astronomical and Geographical Societies of London. The Manchester Steam Users Association of Manchester, England. The Austrian Society of Engineers and Architects, Vienna. From the American Philosophical Society, Philadelphia. The Smithsonian Institution, at Washington. The U. S. Coast Survey, Washington, D. C. And from Prof. J. E. Nourse, U. S. N.

The Committee appointed to investigate the subject of the Horse-power of Steam Boilers reported progress.

The Secretary then read his Monthly Report on Novelties in Science and the Mechanic Arts, after which the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, Oct. 18th, 1871.

The meeting was called to order by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers and reported that, at their last meeting held October 11th, donations to the library were received from

The New York Canal Commissioners. Georgia Historical Society. And the Department of the Interior, Washington.

The Committee appointed to investigate the Horse-power of Steam Boilers reported progress and were continued.

Under the head of new business, the President announced that the Board of Managers had approved a resolution of the "Committee on Science and the Arts," awarding the Elliott Cresson Medal to Mr. B. C. Tilghman, for the discovery of a process of cutting and engraving hard substances.

The Secretary then read his Monthly Report on Science and the Arts, after which the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

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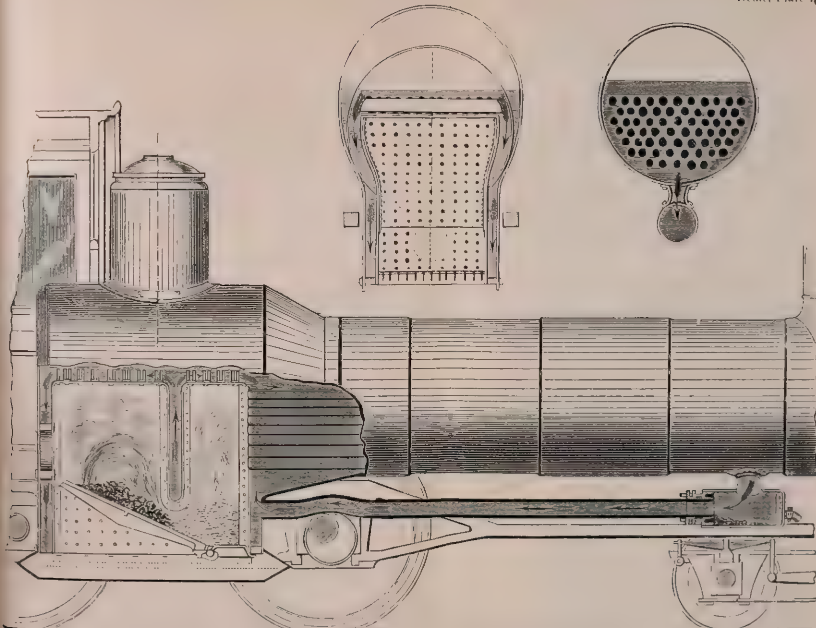


WOODSON'S STEAM BOILER.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXIII.] FEBRUARY, 1872. No. 2

EDITORIAL.

ITEMS AND NOVELTIES.

The Woodson Steam Boiler.—The boiler, of which we herewith present a plate engraving, though containing no essentially new features, yet seems to possess a happy combination of several devices which are universally acknowledged to be of advantage.

The following description, condensed from a more elaborate one, in a contemporary, will serve to explain its construction.

It is based upon the principle that uniform longitudinal circulation will furnish steam at the surface of the water with a uniformly accumulating pressure, and will keep the boiler of very nearly the same temperature throughout its length, thus avoiding the manifold evils which result from the repeated unequal expansion of its different parts. This principle is applicable to boilers of all kinds, while the engraving represents its application to a locomotive boiler.

The inventor, Mr. F. A. Woodson (243 Broadway, New York), seeks to accomplish these desiderata by the attachment of a longitudinal pipe, six inches (more or less according to size of boiler) in diameter, below the boiler proper, and a mud-drum for the deposition

and retention of sediment. The water passes from the end of the boiler remote from the furnace downwards into the mud-drum, thence onward through the pipe to the water-leg at the rear of the furnace, thence upwards into the boiler, delivering up its steam on its passage back again.

The passage of the water through the circulator will be more rapid as the temperature in the furnace is higher, but in all cases it is claimed to be rapid enough to change the entire body of water in a short time. Our cotemporary pays a high compliment to the satisfactory manner in which the circulation is performed, as well as to the removal of the sediment.

The inventor further claims an improvement in evaporative power by the construction of the furnace. The grate, as will be seen on inspecting the plate, is inclined, the highest part being front; the coal thus feeding backwards of its own gravity. A descending bridge-wall, into the interior of which water is flowing, intercepts the uncombined gases generated in the front chamber, while an additional air supply permits of their complete combustion in the second.

Shaw's Compound Propeller Pump.—This invention is the subject of two patents, dated Feb. 15, 1870, and May 30, 1871, and is owned by the Hydrostatic and Hydraulic Company, of Philadelphia, Pa.; office, 67 North Front street. The pump shown in illustration is 36 in. in diameter, and will throw from 25,000 to 30,000 gals. of water per minute, and is designed for drainage purposes, to be used below Delaware City.

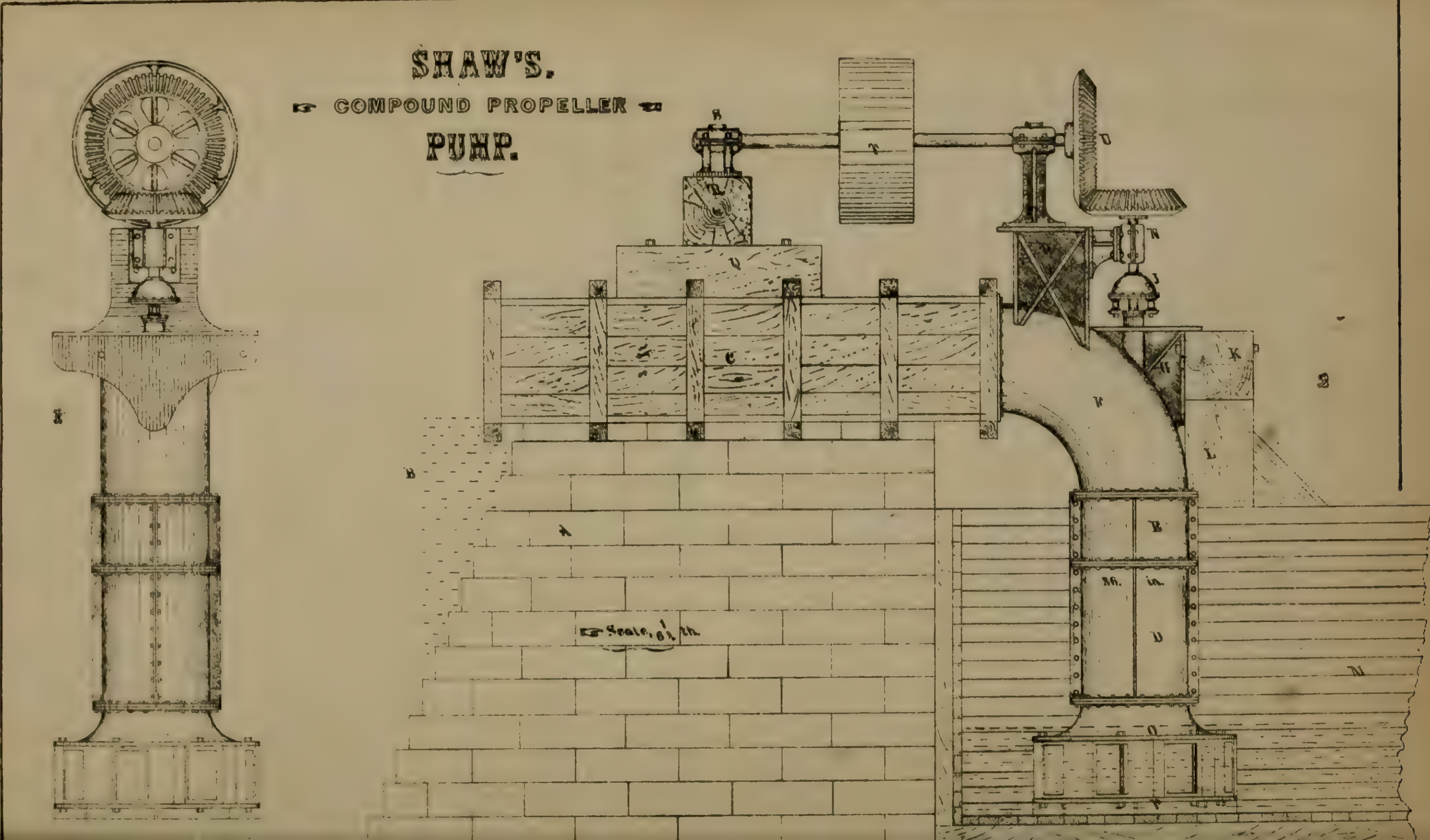
The invention consists of an ordinary pipe, constructed of two semicircular sections for the convenience of access to the interior, upon which sections are cast wings of propeller configuration, two feet apart, between which are rotated upon a shaft, *N* (passing through centre of pipe), ordinary propeller wheels of reverse angle; the combined action of the male thread of rotating propeller and the female thread of stationary wing elevates the water in proportion to pitch of thread and velocity of screw.

The basket, *O*, is intended to keep out objects too large to pass through the pump; the bend, *F*, leads the water into conduit, *C*, through which it is conducted into the river, *B*. *J* is a hydraulic disc to sustain the end thrust of shaft, as it will be observed that the weight of gearing, shaft and water must be sustained whilst rotating, giving an enormous end thrust in pumps of great length, which could

SHAW'S.

COMPOUND PROPELLER

PUMP.



not be practically sustained but for this ingenious invention, which will be illustrated more fully in our next issue. The power is conveyed from an ordinary engine to the pulley on counter shaft, *T*, from which it is transmitted by gearing, *U*, to shaft of pump. The velocity of pump shaft ranges from 150 to 200 revolutions per minute.

It will be evident that the great advantages of this pump are its great simplicity, being little more than an ordinary pipe, being free from valves and complicated machinery, not liable to be clogged by ordinary rubbish, and can be exposed in cold situations without damage from ice, as the water drops out of pump whenever it ceases to rotate.

This pump, from its cheapness and great simplicity, is gradually working its way into the many uses for which it is so admirably adapted.

A Novel Danger Signal.—We are informed that the Hudson River Railroad Co. has constructed danger signals of a new kind at every bridge and tunnel along its route, to warn brakemen who are compelled, in the performance of their duties, to occasionally run along the tops of the cars on the near approach of the train to dangerous places on the line. A pole is erected at the side of the track, carrying at the top an arm at a right angle to it, and projecting over the road. A wire fringe hangs from this, having nearly the width of the car, and low enough to strike a brakeman on the front piece of the cap or on the face, should he be standing as the train passes. This is a warning that the train is 100 feet from a bridge or tunnel, and that he must at once lie down.

The Council Bluffs and Omaha Bridge.—From the report of the Chief Engineer, T. E. Sickels, we glean the following particulars concerning the bridge at present in course of erection for the Union Pacific Railroad Company:

The plan of bridge adopted by the Company comprises 11 spans of iron superstructure, each span 250 feet in length, elevated 50 feet above high water, and supported on one stone masonry abutment and 11 piers formed of cast iron columns, eight and one-half feet in diameter, filled with cement masonry. The foundations of the abutment and piers extend to the bed rock underlying the sand, which is found at an average depth of 60 feet below low water in the river.

The original plan provided for the construction of an ice-breaker column on the up-stream side of each pier, to extend from the bed

rock to high water level, but this was subsequently abandoned as not essential to the safety of the bridge.

A contract for the construction of the bridge was made with L. B. Boomer & Co., of Chicago, in 1868, and the work of sinking iron columns for piers was commenced in February, 1869. The work was afterwards suspended for a period of eight months, and was resumed under a modified contract, which stipulates that the work of sinking columns and erecting superstructure shall be done under the management of the engineer of the railroad company, all the iron work to be manufactured and furnished by the contractors above named.

Since the resumption of the work in April, 1870, the work has been vigorously prosecuted. Ten steam engines have been in use for a greater part of the time, to operate the pneumatic machinery, hoisting cylinders and the iron work of the superstructure into position, &c.

The portions of the iron columns below water were cast in sections of 10 feet each, with internal flanges at the ends, by which means the sections could be securely bolted together. A red lead joint was used to make them air-tight. The wrought iron portion of the column (above high water) is also in sections of ten feet, fastened together by rivets. The thickness of the iron in this portion varies from one-half inch at the bottom to three-eighths at the top. The thickness of the cast-iron portion is one inch and a half. The process of sinking iron columns is similar to that which has been largely used in Europe and in India, and for a few bridges in this country. After sinking as far as possible, the water within the column is expelled by air pressure furnished by a steam pump, and the interior was excavated by laborers to within about two feet from the bottom, when the air pressure was withdrawn and the sinking continued further. The greatest pressure to which the men were subjected was 54 lbs. per square inch in excess of the atmosphere; but, though this is without parallel in work of a similar character, we are informed that they suffered neither injury nor inconvenience.

All the piers are built up to the full height except two, and those are above the level of high water. Four spans of the superstructure are in position, and the remainder will be completed and the bridge ready for use by the 15th of February.

The total cost of the bridge, with the approaches, is estimated to be, in round numbers, $1,650,000, of which, up to Dec. 1st, $1,300,000 have been expended.

A Machine for Testing the Strength of Materials.—Messrs. Riehle Bros., of this city, are building machines, of very simple construction, for this purpose. The plan adopted is that of a weighing machine. Though compact, it is exceedingly powerful, and may be adjusted with the utmost nicety, in order to test with equal accuracy the amount of strain which any given sample of boiler-plate or other metal may be able to withstand. The tool for holding the test pieces is modified in such a manner as to be adapted for a variety of purposes, such as the testing of cast and wrought iron-boiler-plate, girders, bolts, chains, &c.

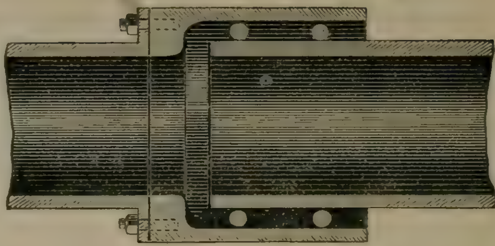
The machine has already attracted much attention, and several orders are now being filled for establishments in other cities. A number of very satisfactory tests we understand have already been made for the Baldwin Locomotive Works in testing boiler-plate.

The Detroit Tunnel.—The following description of the present condition of the work of excavating a tunnel under the strait separating Detroit, Mich., from Windsor, Canada, has been published:

A large coffer-dam, forty feet square, has been constructed by driving down in double rows thick piles, upon which six inch planks were bolted. A solid pier was then formed by ramming in hard blue clay, and through this newly made land the shaft is to be sunk. The base of the iron shaft, fifteen feet in diameter, two feet thick and weighing eight tons, has been placed in position, and upon it brick work, laid in asphalt, has been built to the height of ten feet. The weight of the iron base and brick work will gradually sink the shaft to the required depth of fifty feet, as the earth is taken from beneath. When the bottom is reached the next work will be the excavation of the drainage tunnel, five feet in diameter and twenty five feet below the main tunnels, at the respective entrances, but rising gradually to the central point.

Mechanical Problem.—Required the construction of a valve and its accompanying parts, so that its extreme movement in either direction need not exceed the width of one of the ports; the width of the port being considered equal to one half the movement of the valve. By the accompanying parts is not meant the gearing or mechanism for operating the valve, but such devices—as slides or openings—as are necessary for solving the problem. D. V. W.

An Expansion Joint.—We find in an engineering contemporary the accompanying illustration and description of an expansion joint



for steam pipes, which seems to be a very suitable method of attaining that object.*

From the writer's statement, it appears that in a long line o steam-pipe, arranged to use exhaust steam for heating purposes, the expansion and contraction was so great as to frequently rupture the joints ; and to obviate the difficulty, the form of expansion joint, shown in the above cut, was devised, which, we are told, obviated it entirely.

The two round rubber rings between the outside of the pipe and the inner side ot the sleeve, serve as a packing and roll as the pipe expands or contracts. The rings are made of pure rubber, and of a sectional diameter $\frac{1}{8}$ inch greater than the space between the pipe and sleeve.

On Tilghman's Process of Cutting Hard Substances.—The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the mechanic arts, to whom was referred for examination Mr. B. C. Tilghman's method of cutting and engraving stone, glass, &c., by a blast of sand, report that they have seen the operation as described in the "Journal of the Franklin Institute," for March, 1871, No. 542, pp. 195 to 197. The invention seems capable of extensive use in the arts. Some of the products of the invention seem to present new and valuable features. Glass ornamented by this process can only be compared with that etched by powerful acids, yet the entire absence of all undercutting, no matter how deeply the glass is cut, renders it superior. The great merit of the invention consists in its extended utility. By means of this sand blast effects have been produced which would be hard to imitate by any other known mechanical process, and with an ease and precision truly remarkable. They consider the invention original and of the highest utility, and deem it worthy of any mark of approbation you may see fit to bestow upon its originator.

With this in view, we would respectfully suggest that the Elliott

* Engineering xiii. 8.

Cresson medal of the Franklin Institute be awarded to Mr. B. C. Tilghman, in accordance with the rules governing such award.

All of which is respectfully submitted.

Coleman Sellers, Samuel Sartain,
Charles M. Cresson, M. D., Wm. Struthers.

Breaking up Large Castings.—Mr. P. Champion has experimented upon the use of dynamite for breaking up large masses of metal for subsequent fusion, and announces his results as satisfactory. The author suggests that a number of holes be bored in the mass, and that the charges in each be connected with each other. The explosion of all of them may then be effected simultaneously by means of electricity, and the mass reduced at once into fragments suitable for immediate use.

Cement for Joining Iron.—As a cement for joining pieces of cast-iron or stopping fractures, Winkler recommends the use of the following mixture: Sixteen parts of clean wrought-iron filings, three of powdered sal-ammoniac and two of flowers of sulphur.

When intended for use, it is recommended to reduce the dry mixture (which can be kept for any length of time without change) to the condition of a stiff paste, with the aid of water slightly acidulated with sulphuric acid. When so reduced it must be applied immediately, as it hardens rapidly.

The Rotary Puddling Furnace.—According to a contemporary,* the commissioners sent to this country by the English Iron and Steel Institute, to examine and report upon the operation of Dank's rotary puddler, have made a report favorable to its adoption. In the telegram announcing this conclusion, they state that the furnace is successful, and in point of economy and in the quality of its work, satisfactory. In this report they even go beyond the limit assigned by the inventor, and recommend the construction of furnaces capable of puddling over 1,100 lbs. of iron, and assert that this large mass can be hammered or squeezed into a single ball. The general introduction of the machine puddler will necessitate a complete reconstruction of forges, since it requires that the appliances for hammering and rolling the puddled bloom shall be on a much larger scale than in the ordinary plan of operating, and the adoption of these changes will be a handsome tribute to the merits of the invention.

* Iron and Coal Trades Review.

Copying Drawings by Electricity.—An ingenious method of rapidly copying drawings or engravings is suggested by M. Chanderay,* who uses the induction coil for this purpose. The method adopted for this purpose by draughtsmen usually consists in puncturing holes through the design and thus obtaining an outline, which is subsequently transferred by sifting plumbago or other powder through the holes; a very laborious task where the drawing is large or has much detail.

In the plan proposed, a table covered with tin foil is connected with the negative pole of the inductorium, and on it is placed as many sheets of paper as the spark will penetrate. A metal bar, insulated with gutta percha, serves as the positive pole, and as a pencil for copying the tracings. This point is moved about on the outline of the engraving, and sparks pass through the paper to the tin sheet underlying it every time connection is made, puncturing four holes through the tissue at each passage. It is said that but little skill is required to guide the pencil, as the ink tracings, being good conductors, carry the pencil easily along.

Fog Signals.—C. S. Larned suggests the importance of creating a system of notes, to represent a small dictionary of words, with the fog whistle, by means of which captains of vessels may speak to each other at a distance through a dense fog.

There can be no doubt of the great advantage to be derived by this simple suggestion; its practicability seems to be attended with little difficulty, and if introduced by general consent, it might serve the purpose, in many cases, of saving both life and property, besides curtailing the expenses of many vessels in saving of time; by giving information to masters of vessels of their position, and warning them of danger.

The Planotype.—A contemporary describes a method of obtaining printing surfaces, to which the above name is attached.† The design to be engraved is transferred to a block of lime tree wood, which is then placed in a machine having somewhat the appearance of a sewing machine; but instead of the needle, we find a steel pin (the shape of which varies considerably according to the nature of the work), kept red hot by a gas jet. By means of this contrivance, the design is gradually burnt into the wood. Figures or letters of refer-

* Quart. Journ. of Science, xxxiii. 128.

† The Engineer, xxxiii. 14, from Dingler's Journal.

ence are impressed by means of suitable cut punches. When the design has been completely burnt into the wood, a cast is taken in type metal directly from the block. This cast, we are informed, may be used for printing from, without any additional preparation, precisely like a stereotype plate. It is stated that the wood does not suffer in the slightest degree from the heat of the molten metal, and that the finest detail may be reproduced.

Sodium as an Explosive Agent.—Since writing the former item upon the application of sodium as an explosive, we have received from Prof. Henry Wurtz, of New York, some additional information upon the subject, which is quite interesting, as being the record of the earliest experiments in this direction.

It appears from this, that the device found most effective for practical purposes by Prof. W., consisted in the use of an alloy of potassium and sodium, which is liquid at ordinary temperatures, prepared by the original method of Gay-Lussac and Thenard.

When this liquid alloy is brought into contact with any liquid of which oxygen is a constituent—as water—its decomposing action is far more rapid and energetic than that of the solid metals; so much more energetic, indeed, as to admit of no comparison. This increase in energy is precisely what might be anticipated, since the perfect intermingling of two liquid reagents would greatly facilitate the decomposition; producing a much more intensified action in a given period of time, than with the employment of the solid metal, as described in the former notice.

We are informed, by the same chemist, that he has substituted nitric acid and other substances, rich in oxygen, for water, and with increased effects.

The detail of these experiments was called forth by the recent labor of Springmühl, whose plan was described in our former notice. It would seem, from what has just preceded, that the work of Prof. Wurtz in this direction was far more exhaustive than that of Springmühl, who, to judge from his results, seems not to have been aware of the existence of these earlier experiments.

The amount of power at disposal in the plan under discussion is unlimited enough to satisfy the most exacting, and, in relation to the experiments made with it, it may be remarked that while the ultimate success or failure of the system in practice may be decided by practical considerations which have not yet entered into the dis-

cussion, and which cannot be predicted, the objection named in the previous article—that of wastefulness—is in a great measure obviated by the proposition of Prof. Wurtz to use both reagents in a liquid form.

A Method for Filling Barometer Tubes.—Mr. H. Wild,* after calling attention to the inconveniences and the danger of breaking barometer tubes attendant upon the method usually employed, namely, that of boiling the mercury in the tube, to insure a perfect vacuum, suggests a plan of his own, which is intended to obviate these objections.

A doubly tubulated spherical vessel is connected on one side with the tube to be filled, and on the other, first with a drying tube, and further on with an air-pump.

The spherical vessel is filled partly with the mercury, and the air is successively exhausted and admitted in this and in the tube, in order that the air within the apparatus shall be made perfectly dry by the action of the drying tube. When this is accomplished, a vacuum is produced by the pump, and the tubulated vessel tilted so that the metal may run gently into the barometer tube.

The remaining part of the operation will need no explanation. The author declares that he has operated frequently according to the plan he describes without having in a single instance either broken a tube or failed of success.

The Weather-Waste of Coal.—Dr. Varrentrapp has made this the subject of an investigation, and as a result states that the amount of loss suffered by coal from exposure to weather is considerable, far greater, indeed, than is generally known.

The results of his analyses show in some cases a total loss in weight of a specimen, from this cause, amounting to 33·08 per ct., while its deterioration in quality for purposes of fuel or gas-making reached a still higher figure.

This change consists in a slow combustion, in which the volatile constituents—which are most valuable combustible elements—are gradually eliminated, while the relative proportions of carbon, ash and sulphur are comparatively augmented.

It might be expected, now that the nature of this change is indicated, that anthracite (which has already gone through a very similar process in becoming what it is, by the loss of its bituminous mat-

* Pogg. Annalen cxliv, 137.

ter) should suffer least of all coals from this action, and the result of analysis shows this to be the case. The density and compactness of this variety, aside from its chemical character, protect it in no inconsiderable degree.

The Cannel coals rank next in their power to resist deterioration from this source; while the bituminous varieties are the most susceptible.

The experiments of Dr. Varrentrapp are of such direct and practical importance that all who are engaged in the mining, transportation, storage or consumption of coal can study them with profit.

It appears, from accurate tests of a number of samples before and after exposure, that all the valuable properties of the coal had deteriorated.

The coking quality of the weathered coal diminishes with its gas-yielding quality, the author informing us that a sample of coal yielding, when freshly mined, a firm coherent coke, after eleven days' exposure, yielded a coke of no coherence, and in all the samples tested the rule was absolute that the longer the coal had been exposed the greater was the inferiority in the quality of the coke it produced.

The gas-yielding quality decreased in one instance 45 per ct., and the heating power 47 per ct.; while the same sample under cover lost in the same time but 24 per ct. for gas purposes, and 12 per ct. for fuel.

These experiments go far to explain the almost universal inferiority of the slack or waste coals in heating power when prepared for burning, even though some combustible material like pitch or tar is used in their cementation. It indicates, too, the imperative necessity of keeping coals amply protected from the deteriorating action of the air and moisture by keeping them constantly dry and under cover.

The Mechanical Effect of Magnetization.—Prof. Tyndall, in a recent lecture, describes an interesting experiment, which may perhaps be new to some of our readers, in the following terms: "The effect which I wish to make manifest is this: at the moment when the current passes through the coil surrounding the electro-magnet a clink is heard emanating from the body of the iron, and at the same moment the current ceases a clink is also heard. In fact, the acts of magnetization and demagnetization so stir the particles of the magnetized body that they can stir the air and send sonorous impulses to our auditory nerves.

"The sounds occur at the moment of magnetization and at the moment when magnetization ceases; hence, if a means be devised of making and breaking in quick succession the circuit through which the current flows, we shall obtain an equally quick succession of sounds."

The lecturer then describes the contact breaker, and the position of the bar upon the bridges of a monochord, and continues: "The current is now active, and every individual present hears something between a dry crackle and a musical sound issuing from the bar in consequence of its successive magnetization and demagnetization."

An Electrical Phenomenon.—Prof. S. H. Lockett relates the following observation in a letter from Niagara Falls: "While crossing the new suspension bridge, I had occasion, while conversing with a friend, to point towards the falls with my walking cane. As I did so, I heard distinctly at the end of my cane a buzzing noise. Repeating the experiment, the same noise was heard. I stopped several passers and tried their canes with the same result, except in the case of one which lacked a ferule. I immediately supposed this might be an electrical phenomenon, and set to work to test the correctness of this supposition. I took a key, and held it at arm's length towards the falls, and heard the same sound. Finally, at dark, I returned to the bridge, and pointing my cane, had the satisfaction of seeing a clear, beautiful electric brush on its end.

The best point to observe this interesting phenomenon is in the middle of the bridge, and the cane must be held at arm's length, so that its end may be at some distance from any part of the bridge. The success of the experiment depends a good deal on the direction of the wind, and the amount of vapor blown over the bridge." * *

India-Rubber Tubes and Gas.—We find in a contemporary* a description of a simple experiment showing the permeability of india-rubber to gases. A vessel is constructed with an india-rubber diaphragm, upon one side of which hydrogen is confined, and upon the other, air. In 28 days, 22·6 per cent. of hydrogen was found to have escaped into the air chamber, while 5·9 per cent. of air had entered. This was with vulcanized rubber; when pure rubber was used the diffusion was nine times greater.

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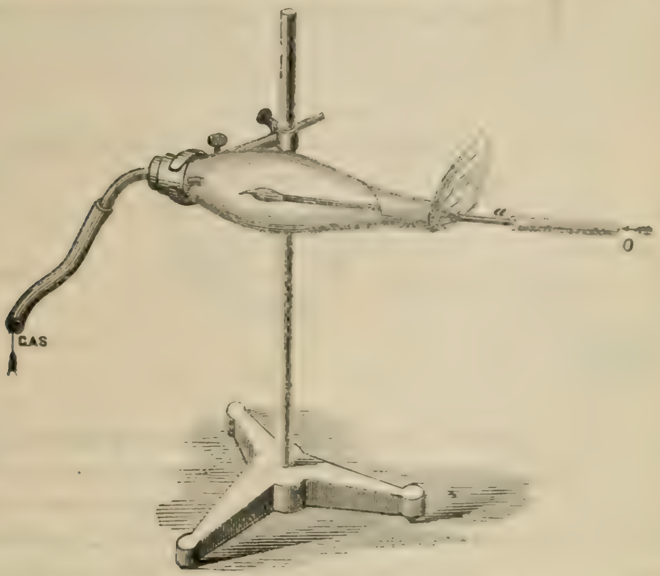
* Journal de l'Eclairage du Gaz.

A Lecture Experiment.—M. Ballo describes the accompanying arrangement by which the singing of reciprocal flames can be effected.*

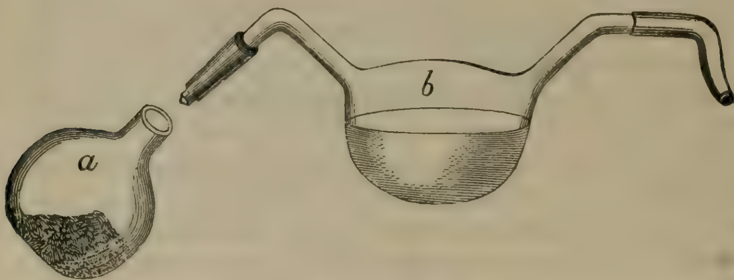


A glass cylinder, such as is used in the petroleum lamp, is attached upon a retort stand at very slight angle from the horizontal position. To one end is fitted a perforated cork, through which a glass tube supplies burning gas. The lower end is open, and protected from breakage by a fold of sheet iron. Oxygen is supplied at the open end by a straight tube drawn out to a fine point. The cylinder is first filled with burning gas and ignited at the lower end; the oxygen tube is then passed into the centre of the cylinder. In passing through the flame it is ignited, and, under these circumstances, produces a singing flame, very similar to that produced by hydrogen flame burned within a tall tube. By using air, the same result may be produced as with oxygen, the cylinder simply requiring to be larger. If the tube supplying the burning gas is in the centre of the cork, the flame will only be set in vibration when in the axis of the cylinder; nearer to the walls, it becomes slightly elongated but emits no sounds.

The effect, we are told, is not easy to be obtained, and a few trials are necessary to properly regulate the flow of the gases for the best results.

* Ber. d. Deutsch. Chem. Gesel., iv, 907.

Apparatus for determining Specific Gravity.—In an article* upon the occurrence of a new mineral in California, and which, in its thoroughness, may serve as a model investigation, Dr. G. E. Moore suggests a very ingenious device for determining specific gravity, which, as it may be serviceable to others in similar cases, is here reproduced.



The substance operated upon was the black precipitated sulphide of mercury, and as it possesses the unpleasant peculiarity of retaining with great tenacity a coating of air, a complete mixture with water was found to be impossible. The use of the air pump was also attended with difficulty from the foaming which ensued.

To meet the difficulty, the device shown in the accompanying figure was contrived. This consists of the ordinary specific gravity flask *a* which is connected with the Bunsen pump by means of the bulbed tube *b*, whose middle part had been widened out into a bulb of equal capacity with the flask, the communications between the bulb tube, which is filled to about three-fourths with water, and the flask being made air-tight by a moist rubber collar. As soon as the manometer of the air pump indicates the maximum of rarifaction, the apparatus is inclined, whereby the water runs gently from the bulb into the flask, penetrating every pore of the mass without forming a particle of scum.

A Method of observing Vibrating Flames.†—A contemporary gives a description of a simple apparatus for observing the phenomena of vibrating or sounding flames.

A disk of white card board is constructed with oblong apertures in a radial direction; this is set upon a spindle so as to admit of rotation at the requisite speed.

* Jour. für Praktische Chemie. n. f.

† Quarterly Journal of Science, xxxiii, 123.

To examine the flame of a gas light, for instance (the flame being protected by a glass tube from the disturbing effects of air currents), place the disk in front of the light, so that the eye can see the light through each slit as it comes to the vertical position.

If now, the speed of the disks' rotation, is such that the interval of time between two slits passing the eye is just equal to the period of a vibration of the flame, the flame appears to be motionless; but if this velocity of rotation be reduced, the flame will be observed to pass slowly through its changes of form.

If the interval is one-half, or one-third of the period of the vibration of the flame, the illusion of a disk having two or three times the number of real slits will be produced. It is only when the periods of flame-vibration and of the over lapping of two successive slits coincide in time, that the flame and disk appear motionless; when this is otherwise, the disk revolves in one direction or the other.

This plan affords a ready means of counting the number of vibrations of a flame, and by substituting a wire for the vibrating flame, the spiral course of the undulations produced in it may likewise be observed. Mr. Chas. Watson, who has described the experiment, has made some very accurate observations upon the times of vibrations of flame within tubes of different dimensions.

The Gases Occluded in Coal.—Dr. E. Mayer has recently examined some German coals, in order to determine the character of the gases absorbed in them, and, as the result of one analysis, which may serve as a fair sample, he found the following constituents: carbonic acid, 16·9; marsh gas, 20·4; nitrogen, 53·3; oxygen, 1·7; heavy carburetted hydrogens, 7·7 per cent. The large proportion of nitrogen, and the small quantity of oxygen, deserve especial notice. The coal experimented upon had been for some time in contact with the air.

A Delicate Test for Manganese.—Dr. Böttger* directs a few grammes of pure chlorate of potassa to be fused in a test-tube, and while fused a minute quantity of the material suspected of containing manganese to be dropped into it. The presence of a minute trace of this substance will, it is asserted, cause the fused mass to assume a more or less decided peach-blossom red color. It may thus be detected in wood, human hair, (especially if reddish), coal, minerals, etc.

* Polytech. Notiz-Blatt.

New Method of Preparing Supersaturated Solutions.—L. C. de Coppet* announces that by using the anhydrous salts in the preparation of these solutions for lecture or other purposes, they can be prepared with much less trouble than by the old plan of dissolving the crystallized and hydrated salts with the aid of heat.

The author employs the anhydrous sulphate of soda or of magnesia, the dry carbonate of soda, &c., and brings small quantities of them at a time into cold water, and is thus enabled to dissolve much more of the salts than can be accomplished at the same temperature with the hydrated bodies. Of sulphate of soda he asserts that five times as much can thus be obtained in solution as of the crystallized material ($Na_2SO_4 10H_2O$), and in all cases the introduction of a small crystal of the substance causes the solutions at once to crystallize.

New Mode of Preparing Oxygen.†—Mr. Mallet proposes to utilize the property which the subchloride of copper possesses, of absorbing atmospheric oxygen, and liberating the same when heated to about 400 F., in the manufacture of oxygen on the commercial scale.

This material, when moistened and exposed to the air, absorbs oxygen, forming an oxychloride. When this is heated, water is first liberated, and upon this the oxygen, leaving the subchloride behind.

This process may, according to the originator of the plan, be repeated as often as desired. One hundred (100) lbs. of the material, it is said, will furnish nearly fifty (50) cubic feet of oxygen at each operation.

New Use for Paraffin.—Dr. Vohl announces that, mixed with benzole or Canada balsam, paraffin affords a much superior glazing for frescoes than soluble glass. By covering the interior of wine casks with a film of pure white paraffin poured in melted, he has effectually prevented the spoiling of the wine, or its evaporation through the wood.

* Comptes Rendus, Dec. 4, 1871.
† Dingler's Jour., cc, 466.

Civil and Mechanical Engineering.

EXPERIMENTAL STEAM BOILER EXPLOSIONS.

By Professor R. H. Thurston.

The public, quite as much as professional engineers, have, from the earliest period in the history of the application of steam to useful purposes, felt a perfectly justifiable distrust of the steam boiler, whatever its form.

Indeed, the greater our familiarity with that powerful instrument, the more thoroughly do we appreciate the danger which attends its use, and those of the profession who have ever had charge of the machinery of a steam vessel, need not be reminded of the unceasing sense of anxiety and responsibility that, in most cases, has probably oppressed them by day and by night, when steaming, even where they have felt the greatest confidence in the intelligence and zeal of those to whom they have entrusted the care of the boilers.

Such terrible disasters as that which occurred on the *Westfield* last summer, and the epidemic of explosions that have signalized the last few months, have thoroughly re-awakened and intensified the apprehensions so universally felt.

It is to be hoped that a useful result may be a more earnest and intelligent investigation of the subject, and such additional legislation as may make the system of governmental inspection far more efficient than it is at present in the prevention of dangerous explosions.

During a few years past a number of accomplished engineers have been called, by the character of their duties, to investigate the circumstances attending nearly every case of steam boiler explosion in Great Britain, and recently many cases in the United States have been examined with similar care and skill.

A committee of the most experienced and talented among British engineers has also recently given attention to the same subject, with the object of determining what legislation should be recommended, and how far legislation may be expected to remedy this apparently rapidly increasing cause of danger to the public.

The very considerable amount of information thus obtained has been extremely useful in dispelling many of the strange superstitions

and extraordinary theories, of which both ignorance and intelligent but misdirected ingenuity have been wonderfully prolific. The conclusion which has been arrived at, after the examination of many hundreds of cases of accidental steam boiler explosion, is that such so-called accidents are the result of neglect or ignorance, and are never to be attributed to causes which are not, or may not be, easily understood by persons of ordinary intelligence. It is believed that most of these causes are now understood, that they are few in number and are readily controlled by the exercise of intelligence and vigilance.

A *direct proof* of these deductions is, however, still needed, and this can only be obtained by a series of experiments made with direct reference to the production of such proof. Such experiments would be the exploding of boilers under, as nearly as possible, the conditions observed in practice and carefully studying the influence that variations of those conditious may have upon the nature and intensity of the resulting effects.

Comparatively little has yet been done in this direction. More than thirty-five years ago, a committee of the Franklin Institute made a series of experiments of such extent and accuracy that the republication of their reports, and their circulation among engineers, would to-day be a public benefaction.* Their reports, together with the paper of F. A. Paget, on the "Wear and Tear of Steam Boilers,"† and the little book of E. B. Martin‡ on explosions, should be in the library of every engineer.

The experiments of the committee of the Franklin Institute were made upon a small scale, and upon constructions quite different in form from most steam boilers, and, although the information obtained was invaluable, it still remained desirable to repeat their experiments and to make other investigations with boilers of full size, such as are used in steamers, on our railroads, and in our manufactories.

The only experiments of this kind ever attempted were probably those referred to by the President of the Franklin Institute, in his letter published in the concluding number of the last volume of this *Journal*.

It was intended to defer an account of their origin and progress until the completion of the series, but as cold weather has interrupted

* *Vide* Journal Franklin Institute, 1836, Vol. XVII.

† Ibid., 1865, Vol. I.

‡ Records of Steam Boiler Explosions; E. B. Martin: London: E. & F. N. Spon, 1871.

operations, and as the work will not be resumed until spring, it is considered advisable to describe the experiments already made.

These experiments were projected and conducted by Mr. Francis B. Stevens, of Hoboken. They were planned several months ago, and at the request of Mr. S. the United Railroad Companies of New Jersey, with an intelligent appreciation of the importance of such an investigation, both to themselves and to the public, appropriated the sum of ten thousand dollars to enable Mr. Stevens to enter upon a preliminary series of experiments. They, at the same time, invited other railroads and owners of steam boilers to coöperate with them, and offered the use of their shops for any work that might be considered necessary or desirable during the progress of the work.

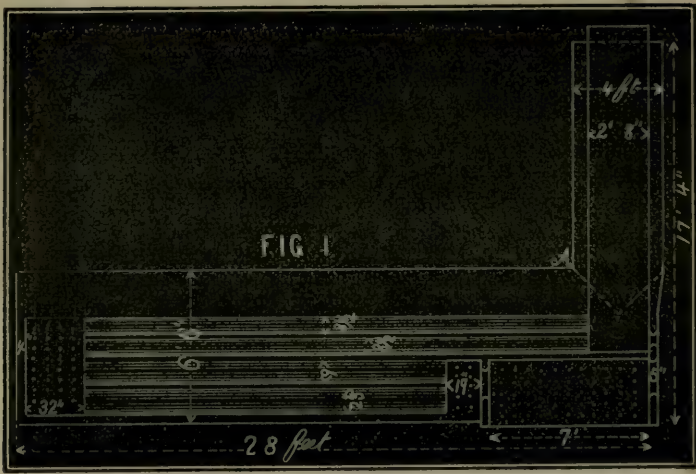
Several old boilers had recently been taken out of the steamers of the United Companies. These were subjected to hydrostatic pressure, until rupture occurred, were repaired and again ruptured several times each, thus detecting and strengthening their weakest spots, and finally leaving them much stronger than when taken from the boats. The points at which fracture occurred and the character of the break were noted carefully at each trial.

After the weak spots had thus been felt out and strengthened, the boilers were taken, with the permission of the War Department, to the U. S. reservation at Sandy Hook, at the entrance to New York Harbor, and were there set up in a large enclosure which had been prepared to receive them. This work was one of great difficulty, but it was skilfully performed, and was accomplished without accident, and the four old steamboat boilers above referred to, together with five new boilers built for the occasion, were placed in their respective positions without having been in any way injured.

Finally, on the 22d and 23d of November, the experiments to be described were made. A large party of gentlemen, many of whom were professional engineers, and all of whom were deeply interested in the subject, were invited to attend, by Mr. S., on behalf of the United Railroad Companies of New Jersey.

The first boiler attacked was an ordinary "single return flue boiler." Figure 1.

The cylindrical portion of the shell was 6 feet 6 inches diameter, 20 feet 4 inches long, and of iron a full quarter inch thick. The total length of the boiler was 28 feet, the steam chimney was 4 feet diameter, 10½ feet high, and its flue was 32 inches diameter. The two furnaces were 7 feet long, with flat arches. There were ten lower



flues, two of 16 and eight of 9 inches diameter, and all were 15 feet 9 inches long: there were twelve upper flues, $8\frac{1}{2}$ inches in diameter, and 22 feet long. The total grate surface was $38\frac{1}{2}$ square feet, heating surface 1350 square feet. The water spaces were 4 inches wide, and the flat surfaces were stayed by screw stay-bolts at intervals of 7 inches.

This boiler was one of a pair built by Fletcher, Harrison & Co., of New York, for the steamer *Joseph Belknap*, in 1858, and, with its fellow, which was also on the ground, had seen 13 years of service. The last Inspector's certificate had allowed 40 pounds of steam. The upper portion of the boiler, when inspected before the experiment, seemed to be in good order. The girth seams on the under side of the cylindrical portion had given way, and had all been patched before it was taken out of the boat. The water legs had been considerably corroded.

In September last, in presence of several gentlemen who had been invited to witness the test, this boiler had been subjected to hydrostatic pressure, giving way by the pulling through of stay-bolts at 66 pounds per square inch. It was repaired and, afterward, at Sandy Hook, was tested without fracture to 82 pounds, and still later bore a steam pressure of 60 pounds per square inch.

On its final trial, November 22d, a heavy wood fire was built in the furnaces, the water standing 12 inches deep over the flues, and, when steam began to rise above 50 pounds, the whole party retired to the gauges, which were placed about 250 feet from the enclosure, and

which had been there proved to give accurate indications. The notes of pressures and times were taken as follows:

Time.	Pressure.	Time.	Pressure.	Time.	Pressure.	Time.	Pressure.
2.00 P.M.	58 lbs.	2.15 P.M.	87 lbs.	2.25 P.M.	91½ lbs.	2.40 P.M.	91½ lbs.
2.05 "	68 "	2.20 "	91½ "	2.30 "	91 "	2.45 "	91 "
2.10 "	78 "	2.23 "	93 "	2.35 "	91½ "	2.50 "	90 "

The pressure rose rapidly until it reached about 90 pounds,* when leaks began to appear in all parts of the boiler, and at 93 pounds a rent at (A, Fig. 1) the lower part of the steam chimney where it joins the shell becoming quite considerable, and other leaks of less extent enlarging, the steam passed off more rapidly than it was formed. The pressure then slowly diminishing, the workmen extinguished the fires by throwing earth upon them, and the experiment thus ended.

The second experiment was made with a small boiler (Figure 2),

FIG. 2.

which had been constructed to determine the probable strength of the stayed surface of the *Westfield's* boiler. It had the form of a square box, 6 feet long, 4 feet high, and 4 inches thick. Its sides were $\frac{5}{16}$ inch thick, of the Abbott Iron Company's "best flange fire-box" iron. The water space was 3⅝ inches wide. The rivets along the edges were ¾ inch diameter, spaced 2 inches apart. The two sides were held together by screw stay-bolts, spaced 8¾ and $9\frac{3}{16}$ inches, and their ends were slightly riveted over, precisely copying the distribution and workmanship of that water leg of the *Westfield*, which was formed between the back connection and the back end of the boiler. It had

* The ultimate strength of this boiler, when new, was probably equal to about double this pressure.

been tested to 138 lbs. pressure. This slab was set in brickwork, about five-sixths of its capacity occupied by water, and fires built on both sides. Pressure rose as shown by the following extract from the note book of the writer :

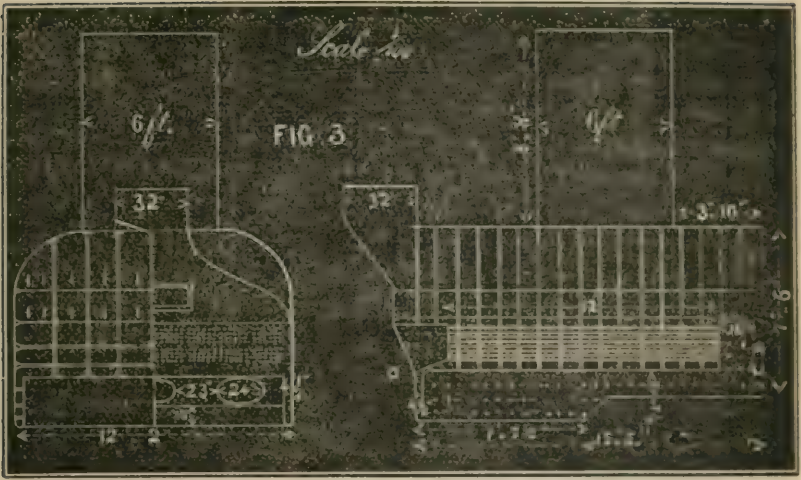
Time.	Pressure.	Time.	Pressure.	Time.	Pressure.	Time.	Pressure.
3.18 P.M.	0 lbs.	3.27 P M.	18 lbs.	8.35 P.M.	49 lbs.	3.43 P.M.	94 lbs.
3.20 "	4 "	3.28 "	20 "	3.36 "	51 "	3.44 "	100 "
3.21 "	5 "	3.29 "	23 "	3.37 "	54 "	3.45 "	110 "
3.22 "	7 "	3 30 "	27 "	3.38 "	58 "	3.46 "	117 "
3.23 "	9 "	3.31 "	30 "	3.39 "	65 "	3.47 "	126 "
3.24 "	11 "	3.32 "	34 "	3 40 "	72 "	3.48 "	135 "
3 25 "	13 "	3 33 "	38 "	3.41 "	78 "	3.49 "	147 "
3.26 "	15 "	3.34 "	44 "	3.42 "	86 "	3.50 "	160 "
						3.51 "	165 "
						Exploded.	

At a pressure of slightly above 165, and probably at about 167 lbs., a violent explosion took place. The brickwork of the furnace was thrown in every direction, a portion of it rising high in the air and falling among the spectators near the gauges ; the sides of the exploded vessel were thrown in opposite directions with immense force, one of them tearing down the high fence at one side of the enclosure, and falling at a considerable distance away in the adjacent field ; the the other part struck one of the large boilers near it, cutting a large hole, and thence glanced off, falling a short distance beyond.

Both sides were stretched very considerably, assuming a dished form of 8 or 9 inches depth, and all of the stay-bolts drew out of the sheets without fracture and without even stripping the thread of either the external or the internal screw ; this effect was due partly to the great extension of the metal, which enlarged the holes, and partly to a rolling out of the metal as the bolts drew from their sockets in the sheet.

Lines of uniform extension seemed to be indicated by a peculiar set of curved lines cutting the surface scale of oxide on the inner surface of each sheet, and resembling closely the lines of magnetic force called, by physicists, magnetic spectra. These curious markings surrounded all of the stay-bolt holes.

The third experiment took place on the 23d of November. The boiler selected on this occasion is shown in Figure 3. It was a "return tubular boiler," with no lower flues ; the furnace and combustion chamber occupying the whole lower part. Its surface extended the whole width of the boiler, thus giving an immense crown sheet, which



was perfectly flat, and was braced to the shell by "crow-foot" braces whose rods were in section 2 inches by $\frac{1}{2}$ inch, and spaced 12 inches lengthwise and 17 inches crosswise the boiler; each brace sustained an area of 204 square inches. The water legs were secured by stay-bolts of 1 inch diameter, spaced 12 inches by 8. The horizontal braces were spaced 28 inches by 12, and were $1\frac{1}{8}$ inches diameter. The shell was of No. 3 iron, single riveted. There were 384 tubes, 2 inches diameter and 12 feet long. The steam drum was placed at the middle of the boiler, and was 6 feet diameter, and 8 feet 8 inches high.

This boiler was built in 1845, by T. F. Secor & Co., and had been at work *twenty-five years*; when taken out, the inspector's certificate allowed 30 lbs. of steam. In September it was subjected to hydrostatic pressure, which at 42 pounds broke a brace in the crown sheet, and at 60 pounds, 12 of the braces over the furnace gave way, and allowed so free an escape of water as to prevent the attainment of a higher pressure. The broken parts were carefully repaired, and the boiler again tested at Sandy Hook to 59 lbs., which was borne without injury, and afterward a steam pressure of 45 lbs. left it still uninjured. At the final experiment, the water level was raised to the height of 15 inches above the tubes, and it there remained to the end. The fire was built, as in the previous experiments, with as much wood as would burn freely in the furnace, and the record of pressures was as follows:

Time.	Pressure.	Time.	Pressure.	Time.	Pressure.
12.21 P.M.	29½ lbs.	12.27 P.M.	41 lbs.	12.32 P.M.	50 lbs., brace broke.
12 23 "	33½ "	12.29 "	44½ "	12.33 "	52 "
12.25 "	37½ "	12.31 "	48½ "	12.34 "	53½ " exploded.

When a pressure was reached of 50 pounds per square inch, a report was heard which was probably caused by the breaking of one or more braces, and at 53½ pounds, the boiler was seen to explode with terrible force. The whole of the enclosure was obscured by the vast masses of steam liberated ; the air was dotted with the flying fragments, the largest of which—the steam drum—rising first to a height variously estimated at from 200 to 400 feet, fell at a distance of about 450 feet from its original position. The sound of the explosion resembled the report of a heavy cannon. The boiler was torn into many pieces, and comparatively few fell back upon their original position.

The same bulging of stay-bolted surfaces that was noticed in the preceding experiment was observed here, and the screw stay-bolts slipped out as before, without breaking and without stripping their threads. The braces were usually broken at the welds.

Having briefly described these experiments, it may be well to notice what bearing their results have upon existing beliefs, and how far they extend our knowledge of the causes and conditions of explosions.

In the first experiment, we probably have an illustration of by far the most usual behavior of steam boilers, when yielding to over-pressure. The pressure gradually rising, ruptured the boiler at its weakest point, which happened to be a spot of merely *local* weakness ; the rent extended toward stronger portions, but soon became large enough to discharge the steam as rapidly as it was made. The strength of the metal in the direction of the line of fracture being sufficient to resist further extension at the maximum pressure attained, no greater injury was done. The spot being patched, the boiler is probably still capable of doing good service for a considerable length of time.

When boilers give way from excessive weakness or from over pressure, they very generally do so in the manner described. The explosion is the exceptional case, and the frequency with which old boilers "blow out" in every part, though usually about the stayed surfaces, and the apparent impunity with which they are kept at work after being frequently patched, has probably been the most in-

fluential cause of the existence of the belief, which is, unfortunately, widespread among engineers, that the mere pressure of steam cannot cause explosions, and that, if the boiler contains a sufficient quantity of water, it is perfectly safe, except against sundry mysterious forces, which are probably, like the fairies and ghouls of earlier times, existent only in the imaginations of those whom they terrify.

In the second and third experiments, we have illustrations of the comparatively rare cases in which explosions actually occur.

The second was a perfectly new construction, in which corrosion had not developed a point of great comparative weakness, and the edges yielding along the lines of rivetting on all sides simultaneously and very equally, the two halves were completely separated, and thrown far apart with all of the energy of unmistakeable explosion, although there was an ample supply of water, and the pressure did not exceed that frequently reached in locomotives and on the western rivers, and although the boiler itself was quite diminutive.

The circumstance of the drawing out of the stay-bolts without breaking and without stripping their threads, was one of the most interesting points of the experiment.

Constructing a formula upon the very probable hypothesis that this was an example of average American practice, we obtain for ordinary use $d = \frac{365\,t}{\sqrt{f\,P}}$; where d = the distance between staybolts, t = the thickness of the plates, P = the pressure f and = the factor of safety which certainly *ought, in no case, to be less than six.*

Also $P = f\left(\frac{365\ t}{d}\right)^2$, the units of measure being lbs. and inches.

Fairbairn proved, by experiment, that the diameter of screwed stays should be double the thickness of the sheet, in order to make their tensile strength equal to the force that would draw them out of the sheets. To this should be added ¼ inch allowance for corrosion. These staybolts should have been ⅞ inch in diameter, the ¼ inch excess of diameter being comparatively valueless.

The spacing of the staybolts, in a boiler of such workmanship, intended to carry 40 pounds of steam, and taking six as a factor of safety, should, however, have been $d = \frac{365 \times \frac{5}{16}}{\sqrt{6 \times 40}} = 7{\cdot}3 +$, or about 7½ inches.

Fairbairn showed that properly rivetting over the ends, increased the strength of staybolts 14 *per cent.*

In the third experiment, as in the second, it is probable that the weakest part extended very uniformly over a large part of the boiler, either in lines of weakened metal, or over surfaces largely acted upon by corrosion. Immediately upon the giving way of its braces, fracture took place at once in many different parts.

In this example, the boiler had been standing a week with steam up, but with none blowing off, and feed being pumped in, unless to supply the insignificant waste from leakage. It was set on solid ground, and the water which it contained could not have been in the slightest degree agitated. It has been a question whether the water might not, under these circumstances, have become super-heated, as in the cases first noticed by M. Deluc, and since investigated by MM. Downy, Dufour and others, and whether the violence of this explosion may not have been largely due to such action.

When it is remembered, however, that those experimenters found it difficult to induce this condition in metal vessels with even minute quantities of water, and that the extent of this super-heating becomes quite small with very small quantities of the fluid, growing rapidly less as the bulk of water increases, it may be very much doubted whether it would be possible to obtain such a state in this case, where tons of water were contained in a rough metal vessel, and also where a circulation was constantly kept up by a fire at one end.

The quantity of heat thus stored up must have been very small, even if there were any such excess.

Were it known precisely to what height the steam drum, for example, was thrown in this case, it would be easy to determine with great certainty, whether the steam released at 53½ lbs. pressure was sufficient to produce the effects noted.

We have made such an estimate, but the data are too unreliable to admit of its publication, although it confirms our opinion that no super-heating of the water in the boilea took place.

We may conclude, then, from the result of Mr. Stevens' experiments :—

First, That "low water," although undoubtedly one cause, is not the only cause of violent explosions, as is so commonly supposed, but that a most violent explosion may occur with a boiler well supplied with water.

This was shown on a small scale by the experiments of the committee of the Franklin Institute above referred to.

Second, That what is generally considered a moderate steam pres-

sure may produce the very violent explosion of a weak boiler, containing a large body of water, and having all its flues well covered.

This has never before, we believe, been directly proven by experiment.

Third, That a steam boiler may explode, under steam, at a pressure less than that which it had successfully withstood at the hydrostatic test.

The last boiler had been tested to 59 lbs., and afterward exploded at 53½ lbs. This fact, too, although frequently urged by some engineers, was generally disbelieved. It has now been directly proven.*

There can now be no excuse for the implicit confidence so generally felt in the use of the hydrostatic test, or for not at least combining with it, in every inspection, the use of the "hammer test" by experienced inspectors.

It may be finally remarked, that welded boiler braces, and screw stay-bolts which have not nuts at their end or are not well riveted over, should evidently be distrusted.

This extremely interesting and important series of experiments will be continued on the return of warm weather, and it is hoped that Congress may be induced to make provision for its extension. A very excellent report, made to the Secretary of the Navy, by Chief Engineers Isherwood, DeLuce and S. Albert, has been printed by Mr. Stevens, together with a memorial, asking Congress to take action in this matter, which is of such great importance to the public. These will be circulated among those who may be willing and able to aid in the plan proposed.

It is proposed by Mr. Stevens, in the experiments succeeding those now prepared, to determine the conditions of explosion with low water, to examine into the effect of opening the safety valve suddenly upon

* A number of instances of this kind, though not always producing an explosion, have been made known to the writer.

Two boilers at the Detroit Water Works, in 1859, after resisting the hydrostatic test of 200 lbs. with water, at a temperature of 100° Fahr., broke several braces each at 110 and 115 lbs. steam pressure respectively, when first tried under steam.

The boiler of the U. S. steamer Algonguin was tested with 150 lbs. cold water pressure, and broke a brace at 100 lbs. when tried with steam.

A similar case occurred in New York, a few years ago, and the boiler exploded with fatal results,

These accidents are probably caused by changes of form of the boiler, under varying temperature, which throw undue strain upon some one part, which may have already been nearly fractured.

an already heavily strained boiler, and to check those experiments that seem to prove explosions to occur from excessive pressure, by leading steam at high pressure into a comparatively weak boiler containing no water. It is intended to explore this wide field of research as thoroughly as available time and money will allow.

It is to be hoped that our wealthy railroad corporations and owners of steam vessels may see how deeply their own interests are involved in the prosecution of such researches, and that they, as well as the general government, may assist in continuing these investigations.

Stevens' Institute of Teehnology, Hoboken, N. J., Dec., 1871.

PROBLEM OF THE RAFTERS.

By De Volson Wood.

The sloping timbers at the ends of a roof truss are called rafters, whether the truss is a "King Post," a "Queen Post" or other form. When the load is applied at the joints of the truss, the solution seems to present little or no difficulty;—at least authors do not differ in their results. But when the load is uniformly distributed over the rafter, or is applied at points along the rafter, authors differ in their results, as may be seen by examining Trautwine's Engineer's Pocket Book, pp. 247–252. Mr. Trautwine gives his own solution, and refers to Rankine's Civil Engineering, p. 470, for the solution which is commonly given. I find, according to the solution given below, that the horizontal pressure at the upper end is the same as that given by Prof. Rankine, but the longitudinal compression along the rafter is not correctly given by any author so far, as I am acquainted with them.

In order to simplify the problem as much as possible, we will at first consider a single rafter supporting a single weight P, which is applied at any point. · The lower end of the rafter, B, is held in the usual way by resting upon a support which sustains the vertical pressure, and by a tie rod which resists the horizontal push. The upper end is held by a horizontal force, which in any case is sufficient to hold the system in equilibrium.

In Fig 1 let

A B = the length of the rafter.

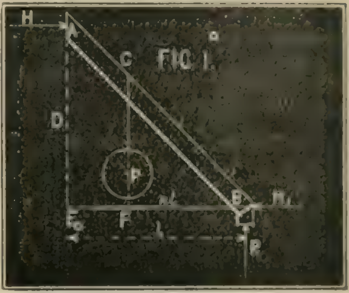
D = A E = the rise.

l = E B = the run of the rafter, or its horizontal projection.

$n\,l$ = B F = the horizontal distance of the point of application of the weight from B.

θ = the angle B C F = B A E.

$P =$ the weight which is applied at C.
$P_1 =$ the reaction of the support B.
$H =$ the horizontal pressure at A.
$H_1 =$ the horizontal pressure at B.



It is a principle of statics that the algebraic sum of the vertical components of all the forces in a system in equilibrium is zero,—and the same is true of all the horizontal components. Or, in this case, the sum of all the forces acting downwards, equals the sum of all those acting upward; and the sum of the horizontal forces pressing to the right equal those pressing towards the left. Hence

$$P = P_1, \text{ and}$$
$$H = H_1.$$

Taking the moments about B we have

$$H\,D = P\,n\,l$$

$$\therefore\ H = n\,P\,\frac{l}{D} = n\,P \tan\theta \quad . \quad . \quad . \quad (1)$$

Taking the moments about A, we have

$P_1\,l = H_1\,D + (1-n)\,P\,l$ or making $P = P_1$ we have

$$P\,l = H_1\,D + (1-n)\,P\,l$$

$$\therefore\ H_1 = n\,P\,\frac{l}{D} = n\,P \tan\theta \text{ as before;}$$

Or, assuming that $H_1 = H$ and we have

$P_1\,l = H\,D + (1-n)\,P\,l$, in which substitute the value of H from (1) and we have

$$P_1\,l = n\,P\,l + (1-n)\,P\,l$$

$$\therefore\ P_1 = P \text{ as before.}$$

Next find the compression along the rafter.

Instead of the single horizontal force at A, we may substitute two other forces such that the resultant of the two shall equal H. The two forces will evidently produce the same result as H. As we seek the longitudinal effect, let one of the components be taken in that direction and call it L^1. The other com-

ponent, to produce no longitudinal effect, must be perpendicular to the rafter. Call it N^1. These forces are shown in Fig. 2.

Hence, we immediately have

$$L^1 = H \sin\theta = n\,P \text{ tang } \theta \sin\theta = n\,P \frac{\sin^2\theta}{\cos\theta} \quad . \quad . \quad (2)$$

$$N^1 = H \cos\theta = n\,P \text{ tang } \theta \cos\theta = n\,P \sin\theta \quad . \quad . \quad (3)$$

The latter component N^1 produces only bending, and is resisted by a component of the applied weight, P. The former component produces compression only, and is the only compressive force between A and C. At C this force is increased by a component of the weight.

Let $N =$ the normal component of P, and

$L =$ the longitudinal component of P.

Then $N = P \sin\theta$, and . . . . . (4)

$L = P \cos\theta$ . . . . . . (5)

Between C and B the total longitudinal compression is

$$\text{L}^1 + \text{L} = \text{n P} \frac{\sin^2\theta}{\cos\theta} + \text{P} \cos\theta = \frac{\text{P}}{\cos\theta}\Big[n \sin^2\theta + \cos^2\theta\Big] \qquad (6)$$

As a check upon the work we may find the reactions of the forces at B.

For H we have the two components

$$L^1 = H \sin\theta.$$
$$N^1 = H \cos\theta.$$

And for P we have

$$L = P \cos\theta.$$
$$N = P \sin\theta.$$

Hence, the resultant longitudinal pressure is

$$L + L^1 = P\cos\theta + H \sin\theta = \frac{P}{\cos\theta}\Big[n \sin^2\theta + \cos^2\theta\Big] \text{ as before.}$$

The resultant normal pressure is

$$N - N^1 = P\sin\theta - H\cos\theta = P\sin\theta - n\,P\sin\theta = (1-n)\,P\sin\theta \quad (7)$$

Adding (3) and (6), we have

$$P \sin\theta,$$

which is the same as (4), as it should be, since the normal pressures at the ends should be equal and opposite to the normal component of the applied weight.

DISCUSSION.

1. If the rafter is vertical, $\theta = o$, and the compression on the upper part, between A and C is, from (2)

$$L^1 = o,$$

and the compression on the lower part, between C and B, from (6), is

$$L = P$$

and the horizontal thrust is, from (1), equal to zero.

2. If the rafter has any inclination and P is placed at A, n is equal to 1 in all the equations, and (1) gives

$$H = P \text{ tang } \theta,$$

which is the value given for this case by all writers. Equation (2) gives

$$L^1 = P \text{ tang } \theta \sin \theta,$$

but, as in this case, C falls upon A, and hence A C = o, this merely gives the component of H in that direction and does not give the compression upon any finite length of the rafter. Equation (6) gives

$$L + L^1 = \frac{P}{\cos \theta} = P \sec \theta,$$

which is also the value given by all writers for the compression upon a brace where the total load is placed at the upper end of the brace.

3. If P is placed at the lower end of the beam, n = o, and equations (1), (2) and (6) give

$$H = o,$$
$$L^1 = o,$$
$$L + L^1 = P \cos \theta;$$

the last of which is the longitudinal component of P, but as in this case C falls on B the resultant compression does not apply to any finite portion of the rafter.

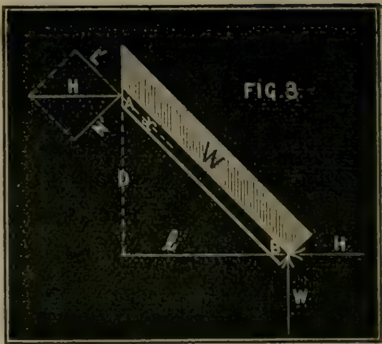
4. Let the rafter be horizontal, then $\theta = 90°$, and equations (1), (2), and (6) become

$$H = \infty$$
$$L^1 = \infty$$
$$L + L^1 = o + \infty$$

5. If P be applied at the middle, $n = \frac{1}{2}$, and we have

$$H = \tfrac{1}{2} P \text{ tang } \theta$$
$$L^1 = \tfrac{1}{2} P \text{ tang } \theta \sin \theta$$
$$L + L^1 = \frac{P}{\cos \theta}\left[\tfrac{1}{2} \sin^2 \theta + \cos^2 \theta\right]$$

By supposing that P is applied at different points, and taking the sum of the results, we may find the effect of several weights applied simultaneously.



Now suppose that the rafter is uniformly loaded over its whole length, and let n = the load on a foot of length of the rafter, and W = the total load.

(Those who compare this solution with Rankine's—*Civil Engineering*, p. 470—will observe that he calls W the load on two rafters, and hence $\frac{1}{2}$ W is the load on one rafter.) Taking the moments about B and observing that the lever arm of W is $\frac{1}{2}\ l$, and we have

$$H\,D = W\,\tfrac{1}{2}\,l \quad \therefore \quad H = \tfrac{1}{2}\,W\,\frac{l}{D} = \tfrac{1}{2}\,W \text{ tang } \theta \qquad . \qquad . \qquad (8)$$

If x be any distance from A measured along the rafter, $w\ x$ will be the load on that length, and the longitudinal component of it will be, according to equation (5),

$$L = w\,x \cos \theta$$

and the longitudinal component of H is,

$$L^1 = \text{H} \sin \theta.$$

Hence the total compression at any section whose distance is x from A, is

$$L + L^1 = w\,x \cos \theta + H \sin \theta = w\,x \cos \theta + \tfrac{1}{2}\,W \text{ tang } \theta \sin \theta, \quad (10)$$

DISCUSSION.

1. At the lower end x = A B, and $w\ x$ becomes w A B = W, and hence *the compression at the lower end is*

$$W \cos \theta + \tfrac{1}{2}\,W \text{ tang } \theta \sin \theta = \frac{W}{2 \cos \theta}\left[2 \cos^2 \theta + \sin^2 \theta\right] \qquad (11)$$

$$= \frac{W}{2 \cos \theta}\left[1 + \cos^2 \theta\right]$$

2. *At the upper end* $x = o$ and (10) becomes

$$\tfrac{1}{2}\,W \text{ tang } \theta \sin \theta = \frac{W}{2 \cos \theta} \sin^2 \theta = \tfrac{1}{2}\,W \sec \theta \sin^2 \theta \qquad . \qquad (12)$$

3. If the rafter is vertical, $\theta = o$ and (10) becomes

$$L + L^1 = w\,x,$$

which at the upper end is zero for $x = o$, as it should, and at the lower end it becomes

$$w\ x \text{ A B} = W$$

as it should since the total load rests upon it.

4. At the middle $x = \frac{1}{2}\, l$, and (10) becomes

$$L + L^1 = \tfrac{1}{2}\, W\,[\cos\theta + \text{tang}\,\theta\,\sin\theta] = \frac{W}{2\cos\theta} = \tfrac{1}{2}\, W \sec\theta \quad (13)$$

5. If the rafter is horizontal $\theta = 90°$, and (10) becomes

$$L + L^1 = 0 + \infty,$$

from which it appears that the compression due directly to the loading is zero; and that due to the resultant horizontal thrust is ∞, as it should be in order to support the weight.

Having deduced, as we believe, the correct formulæ for this case, it will be easy to test the correctness of the formulæ which are deduced by others.

Prof. Rankine, in the reference made above, leaves us to infer that the longitudinal compression will be uniform throughout, and finds its value by assuming that one half the load is supported at each end of the rafter. In this way we readily find that the strain would be

$$\tfrac{1}{2}\, W \sec\theta$$

which compared with (12), (13) and (11) shows that it is too great at the upper end, correct at the middle, and too small at the lower end. If the rafter is vertical the above expression gives $\frac{1}{2}\, W$ for the compression, whereas it should be zero, and at the lower end it is only half enough. The horizontal thrust at the upper end, by this method, is $\frac{1}{2}\, W$ tang θ which is the same equation (8).

Trautwine considers that the total pressure at the foot of the rafter is a vertical force producing compression. This resolved horizontally and obliquely gives

$$H = W\,\text{tang}\,\theta$$
$$L + L^1 = W \sec\theta$$

both of which are double the value given by Prof. Rankine and the former is double the correct value.

This method at first appears so plausible, that it may be advisable to show its fallacy by an illustration.

If P is very near the lower end of the rafter, as in Fig. 4, it is evident that H will be small, while the reaction is still equal to P; and if the weight P is exactly over the support it will develop no horizontal thrust, but in all these cases, according to Trautwine's formula, the horizontal thrust is the same. The longitudinal compression due to P *directly* is constant for all positions of P for the same inclination of the raf-

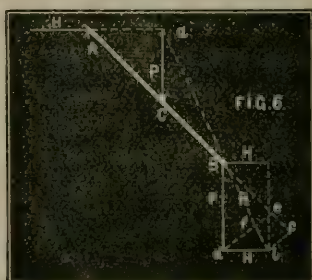
ter, and is $P \cos \theta$; but the compression due to H is dependent upon the position of P, being small when P is near B. Observe that P may be constant and H may have all possible values depending upon the position of P.

If P is considerably above H, as in Fig. 5, the lower end still sustains P and the horizontal thrust greatly exceeds that in Fig. 4. The compression in this case due to P is the same as in the preceding case, while that due to H greatly exceeds that in the preceding case.

It is worthy of note that the strains in this rafter are independent of the inclination of the rafter, brace, or beam, which holds its upper end in any practiced case, *provided* that the two *rest against* each other.

But these illustrations only show the general fact by passing so near the limits of the problem as to make the result appear absurd, but I think they will make the following solution more easily understood. The seat of Mr. Trautwine's error consists in assuming that *the resultant of the two forces at the foot of the rafter is in the direction of the rafter.* This hypothesis is true only when the weight rests upon the upper end of the rafter. The true direction of the resultant may be found geometrically as follows:

Let P, Fig. 6, be applied at any point, then since H and P are in equilibrium about B, the resultant of P and H must pass through that point. It must also pass through the point a where their line of directions meet. Hence a B is the direction of the resultant. If this resultant be resolved parallel to and perpendicular to the direction of the rafter, the former will give the compression between C and B, due to H and P. We have from equation (1) $H = n P \tan \theta$, hence the resultant,



$$R = \sqrt{H^2 + P^2} = P\sqrt{n^2 \tan^2 \theta + 1} = \frac{P}{\cos\theta}\sqrt{n^2 \sin^2 \theta + \cos^2 \theta}$$

To resolve this multiply it by the cos of $b\ B\ c$. Erect $d\ e$ and $b\ c$ perpendicular to $B\ c$, and $b\ f$ perpendicular to $d\ e$. Call $B\ d = 1$, then from,

$$d\,b = \text{n tang}\ \theta,$$
$$d\,B\,c = \theta = f\,d\,b,$$

$$\therefore b\,B = \sqrt{\text{n}^2\ \text{tang}^2\ \theta + 1}$$
$$B\,e = \cos\ \theta, \text{ and}$$
$$f\,b = \text{e c} = \text{n tang}\ \theta \sin\ \theta.$$
$$\therefore B\,c = n \text{ tang}\ \theta \sin\ \theta + \cos\ \theta, \text{ and}$$

$$\cos b\,B\,c = \frac{n \text{ tang}\ \theta \sin\ \theta + \cos\ \theta}{\sqrt{\text{n}^2\ \text{tang}^2\ \theta + 1}} \qquad \frac{n \sin^2\ \theta + \cos^2\theta}{\sqrt{n^2 \sin^2\ \theta + \cos^2\ \theta}}$$

The last expression is found by multiplying the terms of the preceding fraction by cos θ.

The total compressive force is found by multiplying the value of R given above, by the cos of b B c as just found. This gives

$$\text{Compression} = \frac{P}{\cos\ \theta} \sqrt{n^2 \sin^2 + \cos^2} \times \frac{n \sin^2\ \theta + \cos^2\ \theta}{\sqrt{n^2 \sin^2\ \theta + \cos^2\ \theta}}$$

$$= \frac{P}{\cos\ \theta} \left[n \sin^2\ \theta + \cos^2\ \theta\right]$$

which is the same as equation (6.)

If the rafter is uniformly loaded the resultant of the load would pass through the center of the rafter. Calling the load W and proceeding in the same way as above, we find for the *resultant compression at B*

$$\frac{W}{\cos\ \theta} \left[\tfrac{1}{2} \sin^2\ \theta + \cos^2\ \theta\right]$$

$$= \frac{W}{2 \cos\ \theta} \left[\sin^2\ \theta + 2 \cos\ \theta\right]$$

which is the same as equation (11.)

The compression at any point may be formed in the same way by considering the resultant of the weight between A and the point.

ON THE FLOW OF WATER IN RIVERS AND CANALS.

By J. Farrand Henry, Ph. B.

(Continued from page 348.)

In Table XII the observed velocities on these verticals and the ordinates of the parabola are given. The ordinates of other curves have been added for comparison with these observations.

These curves were calculated by the following formulæ :

Parabola. $x = V - (b\,v)\,\frac{1}{2}\left(\frac{y - d}{D}\right)^2$;

in which x = the ordinate at any depth, y,
v = the mean velocity of the river,
V = the velocity at the depth of the axis,
d = the depth of the axis,
b = a constant, the value of which for rivers is given as 0·1856.

Introducing the constants, we have for the

St. Clair, $x = 3{\cdot}580 - 0{\cdot}771\left(\frac{y - 5}{45.4}\right)^2$, and for the

St. Lawrence, $x = 1{\cdot}499 - 0{\cdot}491\left(\frac{y - 5}{65{\cdot}2}\right)^2$.

Reversed Parabola. $x^2 = C + \frac{x^2\,y}{y}$; in which x and y have the same value as the last; and for the St. Clair, $x = 2{\cdot}5$, $y = 47{\cdot}8$, $C = 1{\cdot}591$. For the St. Lawrence, $x = 0{\cdot}624$, $y = 65{\cdot}2$, $C = 0{\cdot}950$.

Logarithmic Curve. $x = C + y\,\frac{1}{a}$; x and y being the same. $C = 1{\cdot}800$, $a = 0{\cdot}77$, for the St. Clair, and $C = 0{\cdot}790$, $a = 2{\cdot}45$, for the St. Lawrence.

Ellipse. $x = C + \frac{B}{A}(2\,A\,y + y^2)\,\frac{1}{2}$; for the St. Clair, $A = 57$, $B = 2{\cdot}7$, $C = 1{\cdot}300$, and for the St. Lawrence, $A = 83$, $B = 0{\cdot}75$, $C = 0{\cdot}818$.

These last curves are the same as those plotted in figures 11, 12 and 13.

The straight lines were taken as intersecting at six-tenths the depth.

Noting first the St. Lawrence observations, we see that in that slow current the ordinates are so small in proportion to the depth that all the curves approximate very nearly to a straight line, and therefore there is but little difference in their agreement with the observations; though even in this case we see that the parabola is the worst form of curve to express the decrease in the velocities.

But in the St. Clair observations, where the velocity is more than double, and the depth much less than that of the St. Lawrence, we see at once how entirely it disagrees with the observations both at the

TABLE XII.

ST. CLAIR RIVER.—DEPTH FROM 44 TO 47 FEET

Depth of Observation.	Velocities. Feet per second.	Parabola. Humphreys and Abbot. Ordinates of Curve.	Difference from Observations	Reversed Parabola. Woltmann. Ordinates of Curve.	Difference from Observations.	Logarithmic Curve. Funk. Ordinates of Curve.	Difference from Observations.	Straight lines, intersecting at 0·6 depth. Defontaine. Ordinates of Lines.	Difference from Observations.	Ellipse. Racourt. Ordinates of Curve.	Difference from Observations.
	3·868	3·564	—0·304	4·091	+0·223	3·952	+0·084	4·000	+0·132	3·964	+0·096
5	3·907	3·573	—0·334	3·957	+0·050	3·886	—0·021	3·892	—0·015	3·916	+0·009
10	3·821	3·564	—0·257	3·814	—0·007	3·812	—0·009	3·784	—0·037	3·843	+0·022
15	3·709	3·536	—0·173	3·662	—0·047	3·725	+0·016	3·676	—0·033	3·744	+0·035
20	3·608	3·489	—0·129	3·476	—0·132	3·623	+0·015	3·568	—0·040	3·618	+0·010
25	3·496	3·423	—0·073	3·318	—0·178	3·501	+0·005	3·460	—0·036	3·460	—0·036
30	3·309	3·339	+0·030	3·117	—0·192	3·342	+0·033	3·260	—0·049	3·260	—0·049
35	3·100	3·237	+0·137	2·885	—0·215	3·121	+0·021	2·943	—0·057	3·005	—0·095
40	2·678	3·115	+0·437	2·604	—0·077	2·751	+0·073	2·627	—0·051	2·671	—0·007
42·4	2·388	3·050	+0·662	2·431	+0·043	2·420	+0·032	2·475	+0·087	2·447	+0·059
45·4	1·428	2·962		2·051		1·800		2·300		2·000	
Sums	33·884	33·890	2·536		1·164		0·309		0·537		0·400
Means			0·254		0·116		0·031		0·054		0·040

TABLE XII—*Continued.*

ST. LAWRENCE RIVER.—DEPTH FROM 64 TO 67 FEET

Depth of Observation.	Velocities. Feet per second.	Parabola. Humphreys and Abbot. Ordinates of Curve.	Difference from Observations.	Reversed Parabola. Woltmann. Ordinates of Curve.	Difference from Observations.	Logarithmic Curve. Funk. Ordinates of Curve.	Difference from Observations.	Straight lines, intersecting at 0·6 depth. Defontaine. Ordinates of Lines.	Difference from Observations.	Ellipse. Racourt. Ordinates of Curve.	Difference from Observations.
	1·542	1·496	—0·046	1·574	+0·032	1·537	—0·005	1·560	+0·018	1·548	+0·006
5	1·533	1·499	—0·034	1·550	+0·017	1·521	—0·012	1·537	+0·004	1·536	+0·003
10	1·509	1·496	—0·013	1·524	+0·015	1·506	—0·003	1·514	+0·005	1·521	+0·012
15	1·507	1·487	—0·020	1·497	—0·010	1·490	—0·017	1·491	—0·016	1·495	—0·012
20	1·470	1·473	+0·003	1·469	—0·001	1·470		1·468	—0·002	1·483	+0·013
25	1·477	1·453	—0·024	1·440	—0·037	1·450	—0·027	1·445	—0·032	1·458	—0·019
30	1·417	1·427	+0·010	1·408	—0·004	1·426	+0·009	1·422	—0·005	1·429	+0·012
35	1·398	1·395	—0·003	1·374	—0·034	1·399	+0·001	1·399	+0·001	1·394	—0·004
40	1·357	1·358	+0·001	1·327	—0·030	1·367	+0·010	1·373	+0·016	1·364	—0·007
45	1·315	1·314	—0·001	1·296	+0·019	1·328	+0·013	1·296	—0·019	1·307	—0·008
50	1·236	1·265	+0·029	1·250	+0·014	1·277	+0·041	1·219	—0·017	1·249	+0·013
55	1·167	1·210	+0·043	1·195	+0·028	1·207	+0·040	1·143	—0·024	1·178	+0·011
60	1·092	1·150	+0·058	1·127	+0·035	1·087	—0·005	1·066	—0·026	1·078	—0·014
62·5	0·800	1·080		0·950		0·790		0·985		0·818	
Sums	18·020	18·025	0·285		0·271		0·183		0·185		0·139
Means			0·022		0·021		1·014		0·014		0·010

surface and bottom. Probably, were the true velocities of the Mississippi known, the differences between them and this parabola would be much greater.

The reversed parabola also differs considerably from the measured velocities; while the logarithmic curve, the straight lines intersecting at six-tenths the depth, and the ellipse, agree very well with the observations. The straight lines cannot be correct near the bottom, on account of the more rapid decrease in the velocities there; to give a close approximation to that part of the velocities, there should be a third line, still more inclined, intersecting the second near the bottom. In the selected vertical from the St. Clair the logarithmic curve appears a little the best; but in the deeper verticals, where the velocity for a considerable depth differs but little from that near the surface, the ellipse shows a much better agreement with the observations; for near the extremity of the minor axis the curve approximates to the tangent at that point.

The great discrepancy shown by the parabola naturally leads us to examine more carefully the manner of obtaining it, especially as we have seen that in full two-thirds of the selected verticals of the Mississippi observations the maximum velocity is at or near the surface.

As has already been stated, Capt. Boileau found that in his observations on the experimental canals at Metz, the decrease in velocities was best expressed by a parabola with its axis at the surface. As these observations are rather curious they are exhibited in figure 13. The velocity below the surface first increases rapidly, then follows closely a vertical line to about one-third the depth, then decreases towards the bottom in nearly a straight line; thus agreeing with M. Defontaine's two straight lines, except that their intersection is at one-third the depth, which is much higher than is given by any other observations

In the Mississippi Report (page 251) these observations are given, reduced to English feet; and the authors found that a parabola with the axis about two-tenths the depth below the surface would agree nearly as well with the observations as one with its axis at the surface, and besides express the decrease above the point of maximum, which Capt. Boileau thought followed in law. This parabola is shown by the full lines in figure 13.

In December, 1859, about a year after the close of the Mississippi observations, Lieut. Abbot made a series of float observations, on a

feeder of the Chesapeake and Ohio canal, at the Little Falls of the Potomac.*

They were very nicely and carefully executed, and are as good as any double float observations can be, and would probably, in such a small stream, give a very near approximation to the true velocity of the current. These observations are plotted in figure 14, being represented by the circumscribed dots.

The canal was rectangular, about 23 feet wide and 7 feet deep.

According to the law of the descent of the maximum velocity, it should be found at about two-tenths the depth below the surface, which is a little less than is given by the observation.

By rejecting the surface and lowest measurement, a parabola similar to the one found to agree with Capt. Boileau's observations would pass very near to the other points. This parabola is shown by the dotted line.

An ellipse, represented by the full line in the figure, passes through the lowest observation, and agrees nearly as well as the parabola with the remainder, while it cuts the bottom at an acute instead of an obtuse angle.

It is to be regretted that this curve was not chosen rather than the parabola, for it certainly better expresses the decrease of the subsurface velocities in flowing water.

Mean Velocity.

Many engineers have attempted to find the ratio between the mean velocity of rivers and canals and the maximum velocity at the surface. Some have been contented with a simple expression of the ratio, and the equation $v = 0{\cdot}8\ V$ is generally adopted, in which $v =$ the mean velocity of the current, and $V =$ the maximum surface velocity. Dubuat gives the formula $v = \frac{V + W}{2}$, W being the bottom velocity. Young makes $v = V + 05 \sqrt{V + 0{\cdot}25}$, V being given in inches per second.

Prony found $v = \frac{V\,(V + 7{\cdot}78188)}{V + 10{\cdot}34508}$, but this gives generally too large a value for v.

Baumgarten multiplied it by 0·8, to make it agree with his observations on the Garonne. The formula then becomes

* Mississippi Report, page 253.

$$v = \frac{0{\cdot}8\ V\,(V + 7{\cdot}78188)}{V + 10{\cdot}34508}$$

the velocities being expressed in feet per second. In this form it will probably give a very close approximation to the mean velocity of rivers.

But the great desideratum has been a formula by which the mean velocity could be obtained from the cross section and inclination of the bed. Almost every writer on this subject has given a new formula, and proved the incorrectness of all those which were established before him.

The oldest and simplest of these formulæ is that of Chezy, $v = C\sqrt{R\,I}$, R being the hydraulic mean radius, or the cross section a divided by the perimeter p. In large rivers this quantity, R, differs but little from the mean depth. I = the inclination of the bed of the stream per running foot, or the fall, h, divided by the distance in feet, l.

C = a constant to be determined by experiment.

The value of this constant has been differently estimated by different writers, varying from 0·68 to 1·00.

Dubuat, from his own observations on small canals and a few others, deduced his celebrated formula,

$$v = \sqrt{R - 01}\left(\frac{307}{\sqrt{\frac{1}{I}} - \frac{1}{2}\,L\left(\frac{1}{I} + 1{\cdot}6\right)} - 0{\cdot}3\right)$$

L being the hyperbolic logarithm, or the common logarithm, multiplied by 2·3025851.

When R and I are both very great, the formula may be written,

$$v = \sqrt{R}\left(\frac{307}{\sqrt{\frac{1}{I}} - \frac{1}{2}\,L\,I} - 0{\cdot}2\right) \text{ nearly.}$$

Dr. Young, in his experiments upon the circulation of the blood, found that the resistances could not be expressed by the simple square of the velocity, and he modified Dubuat's formula as follows:

$$v = \sqrt{\frac{R\,I}{b} + \frac{c^2}{b^2}} - \frac{c}{b},$$ in which $b = {\cdot}0000001\left(413 + \frac{75}{d} - \frac{1440}{d + 12{\cdot}8} - \frac{180}{d + 0{\cdot}355}\right)$, and $c = {\cdot}0000001\,\frac{900\,d^2}{d^2 + 1136} + \frac{1}{\sqrt{d}}\left(1085 + \frac{13{\cdot}21}{d} + \frac{1{\cdot}0563}{d^2}\right)$; d = four times the hydraulic mean depth.

For large rivers $v = \sqrt{20000\ d\ I}$ nearly.

He gives a table of the values of b and c for all ordinary stream and canals. In this and in Dubuat's formula the quantities are expressed in inches, and in all others, in feet.

Eytelwin's well-known formula, the one most commonly used in practice, especially by German engineers, partly on account of its extreme simplicity is, $v = \frac{10}{11} (10560\ R\ I)^{\frac{1}{2}}$.

Darcy and Bazin's formula for streams with natural beds, deduced from their own and preceding observations is, $v\ \frac{\sqrt{R\ I}}{A.}$

A being $= 000085\left(1+\frac{4{\cdot}15}{R}\right)$. For beds of cement, plank, &c., the value of A is different.

Humphrey's and Abbot's formula, obtained from measurements in the small rectangular feeder of the Chesapeake and Ohio Canal and from the selected Mississippi observations, is as follows:

$$v = \left(\sqrt{0{\cdot}0081\ b + \left(\frac{225\ a\sqrt{I}}{p+B}\right)^{\frac{1}{2}}} + 0{\cdot}09\sqrt{b}\right)^{2}$$, in which

B = the width of the stream and

$$b = \frac{1{\cdot}69}{\sqrt{R+1{\cdot}5}}$$

In 1868, after discussing the observation of MM. Darcy and Bazin, Gen. Abbott added a second term to this formula $\_\_\frac{24\sqrt{v'}}{1+P}$.

$v' =$ the value of the first term in the expression for v. He has also prepared tables to facilitate the computation. Dr. Hazen, collating all the observations from which the above formulæ were deduced, and computing the constants by means of the method of least squares, gives the following: $v = 4{\cdot}39\sqrt{R} \times \sqrt[6]{I}$.

The above are a few of the formulæ which have been deduced by different engineers; each one first showing that none of the previous formulæ would conform to their theories and experiments.

At the commencement of this century, Dr. Robinson, of Edinburg, speaking of the state of the science of hydraulics in his day, says: "As to the uniform course of the streams which water the face of the earth, and the maxims which will certainly regulate this agreeably to our wishes, we are in a manner totally ignorant.

Who can pretend to say what is the velocity of a river of which you tell him the breadth, depth and declivity? Who can say what swell will be produced in different parts of its course, if a dam or

wier of given dimensions be made in it, or a bridge be thrown across it; or how much its waters will be raised by turning another stream into it, or sunk by taking off a branch to turn a mill? * * * * * * * * Yet these are most important questions. The causes of our ignorance are the want or uncertainty of our principles; the falsity of our theory which is belied by experience; and the small number of proper observations or experiments, and the difficulty of making such as shall be serviceable."

Dupuit says:* "The comparison of velocities, observed in large bodies of running water is far from confirming the preceding formula;" and he also says that M. Menard states in his "*Cours de Construction*," that he found the actual outflow at a certain point in the river Meuse to be 33·4 m., while Prony's formula, applied to different sections, gave 53 m., 56 m., 74 m., 69 m., 34 m. and 29 m. At another point the computation gave 28 m., 11 m., 30 m., 39 m. and 4m., while the actual discharge was 25 m., 5."

Hints how to use a Grindstone. By T. E. Mitchell, *Phila.*

1st.—Don't waste the stone by running it in water; but if so, don't allow it to stand in water when not in use, as this will cause a soft place.

2d.—Wet the stone by dropping water on it from a pot suspended above the stone, and stop off the water when not in use.

3d.—Don't allow the stone to get out of order, but keep it perfectly round by the use of gas-pipe, or a hacker.

4th.—Clean off all greasy tools before sharpening, as grease or oil destroys the grit.

5th.—Observe—When you get a stone that suits your purpose, send a sample of the grit to the dealer to select by, a half ounce sample is enough, and can be sent in a letter by mail.

* Etudes théoriques et pratiques sur le mouvement des eaux, par I. Dupuit, Paris, 1863, page 55.

Chemistry, Physics, Technology, etc.

ON THE MINERAL RESOURCES OF NORTH CAROLINA.

By Fred'k A. Genth.

(Continued from page 48.)

Copper.—Copper ores have been found in many localities throughout the State, in the veins of the old gneissoid rocks, as well as in the more recent slates, and even in the triassic formation.

The principal ore is chalcopyrite or copper pyrites; and there is every reason to believe that many of the mines require only a fuller development to enable them to furnish large quantities of valuable ores.

I have already mentioned that many of the gold veins are associated with pyritic ores, and in fact almost all the North Carolina copper mines in the central Counties have first been worked for gold, and there are hardly any mines in Guilford, Cabarrus and Mecklenburg Counties occurring in the gneissoid and syenitic rocks, which do not show strong indications of copper ores.

When mining operations receive a new impetus, it is to be hoped that this very important fact will be borne in mind, and that no mine should be started without sufficient means to develop it at once to such a depth that a workable body of copper ores may be reached.

The general character of these mines is that about at water level, the so-called brown gold ores are replaced by quartz richly charged with iron pyrites more or less mixed with copper pyrites, the latter increasing as the mine deepens, and in many places becoming the only, or the predominating ore, and forming a regular copper vein.

The ores either became poor in gold or the latter could not be extracted by the ordinary process, then chiefly in use in North Carolina—Chilean mills and arastra—therefore many valuable mines were abandoned, mostly before a larger and paying quantity of copper ores had been reached.

In this formation there is not at present a single copper mine in operation, although many look favorable for further development.

The principal mines which promised to change into copper mines are: in Guilford County, the Fisher Hill, the North Carolina, the McCulloh, Lindsay, Gardner Hill, Twin Mines, etc.; in Cabarrus

County, the Ludowick, Boger, Hill, Phœnix, Orchard, Vanderburg, Pioneer Mills, etc., and in Mecklenburg the McGinn, Hopewell, Rudesill, Cathay Mines, etc.

The cupreous minerals observed in these mines are, near the surface, small quantities of native copper and cuprite, the latter sometimes in beautiful needles, the so-called chalcotrichite, malachite, rarely azurite, chrysocolla and pseudo-malachite, and in some of the mines chalcocite and barnhardtite; all resulting from the decomposition of chalcopyrite or copper pyrites, which forms the principal ore. Siderite or carbonate of iron often forms an important gangue rock.

A very important copper region extends through many of the western counties of North Carolina, which is best developed in Jackson, Watauga, Ashe, Wilkes and Alleghany Counties. The ores occur in hornblendic slates and gneissoid rocks.

In Jackson County, at the Savannah, the Cullowhee, the Wolf Creek Mines and others, large quantities of chalcopyrite or yellow copper pyrites have been obtained; at Elk Knob, in Ashe County, the ore consists of chalcopyrite with pyrrhotite, in a gangue rock consisting of a dark colored micaceous quartzite. The Ore Knob in the same County has furnished chalcocite or copper glance.

At Gap Creek Mine, in Wilkes County, the ore consists of quartz with bornite or variegated copper ore and chalcopyrite. The ore sometimes contains silver and gold.

The Peach Bottom Mine in Alleghany County has been worked to a depth of 150 feet, and has produced a considerable quantity of ore; galenite occurs in a portion of the vein.

This whole mining region is well worthy the attention of capitalists, and when better facilities for transportation are offered, I have no doubt that it will be more fully and profitably developed.

The only two copper mines in North Carolina, which are worked at present to a limited extent, are in the so-called taconic slates.

The Clegg Mine in Chatham County is a large quartz vein in argillaceous slates. It is developed to a depth of 200 feet and has furnished large bunches of valuable ore. The ore is chiefly chalcopyrite, but other cuprose minerals have been found, among which azurite in small but beautiful crystals. The mine is in excellent order, and the machinery is of the best quality and very efficient. I understand that arrangements have been made to smelt the ores on the spot. Copper ores under similar circumstances are found at other places in Chatham, also in Person County.

The other mine is the so-called Emmons or Davidson copper mine, about six miles from Lexington. It has also been opened as a gold mine, but the ore was poor, containing not over thirty-seven cents per bushel, with a large admixture of iron and copper pyrites, occurring in a dark bluish green chloritic slate. It has been abandoned therefore as a gold mine and is worked only for copper. I learned a few days ago that works for the extraction of the ore by the humid way are in contemplation.

Almost identical in appearance, but richer in gold, is the so-called Barnhardt vein of Gold Hill. In the neighborhood of Gold Hill are several localities which have yielded rich copper ores; especially the Union copper mine in Cabarrus, about one mile from Gold Hill; it was worked more than any other in the neighborhood, and has furnished crystallized copper and cuprite, and a mixture of chalcocite and chalcopyrite and other ores.

Other mines in the neighborhood of Gold Hill, also several in Randolph and Davidson Counties, contain more or less copper; for instance, the Conrad Hill, show strong indications of copper.

Arsenic, Antimony and Bismuth.—Only a few ores of arsenic and antimony have been noticed in North Carolina. Amongst these is very rare native antimony, of which a small piece was submitted to my examination by Dr. Hunter, of Cottage Home, Lincoln County. It has been found in a small vein in Burke County. An examination proved it to be quite pure.

Both arsenic and antimony are found in combination with other metals: arsenic at a few localities in Union and Gaston Counties, in small quantities, as arsenopyrite or mispickel, associated with gold ores; and both arsenic and antimony in the highly argentiferous tetrahedrite of the McMakin, and the tetrahedrite of the Ludowick mines in Cabarrus County.

Bismuth has been observed as bismuthinite in minute particles associated with the gold and copper ores of the Barnhardt vein at Gold Hill, and by Dr. Asbury as bismuthite with gold ores at the Asbury mine in Gaston County; also as bismite, or teroxide of bismuth, in the same mine, and in combination with copper, lead and sulphur at Col. White's mine in Cabarrus County, probably as aikinite. The most interesting ores are the telluride of bismuth (tetradymite) and the tellurate of bismuth (montanite)—both found associated with gold ores in numerous localities—in Davidson, Cabarrus, Gaston, McDowell and

Burke Counties. The bismuthic gold mentioned by Shepard as coming from Rutherford, is probably an artificial product resulting from the simultaneous amalgamation of gold and tetradymite.

Cobalt and Nickel.—Small quantities of these two metals have been observed in the manganese gossans of several mines in Gaston County, but thus far no regular workable deposit has been found.

Manganese.—The regular manganese deposits are as yet known in North Carolina; small quantities of pyrolusite, psilomelane and wad have been observed associated with iron, gold and silver ores, in several localities in the State. Many of the iron ores contain a small per centage of manganese.

The *manganese garnet* may become of considerable importance in the iron industry; it occurs in several large veins or beds. At Buckhorn it is associated with the magnetic iron, and serves as a valuable flux, it is also found near Danbury in Stokes county, in Rowan and Rutherford counties.

Chrome.—Minute quantities are found in the magnetic iron belt passing through Guilford and Rockingham Counties. Deposits of considerable magnitude exist in the chrysolite beds of Jackson, Mitchell, Yancey and Watauga Counties.

None of them are worked at present.

Iron.—Although the mineral wealth of North Carolina is affirmed beyond a doubt by its numerous mines and deposits of gold, copper, silver and other metals, still its greatest resources consist in its vast iron ore beds, distributed throughout the entire State; and when these are properly developed; their importance will by far exceed any other mining interest.

It may be safely predicted that, at an early day, North Carolina will stand foremost as an *iron*-producing State; not only because the various varieties of iron ore exist in inexhaustible quantities, but also because they are of very superior quality, and offer all those requisites to making the better and more desirable grades of *iron* and *steel.*

The principal ores are: the pure magnetic iron, the titaniferous and chromiferous magnetic iron, menaccanite or titaniferous iron, hematite or specular iron, limonite or brown hematite, and carbonate of iron. These ores, especially the magnetites and hematites, being

in reality only a more ferriferous portion of the stratification form strings of large lenticular beds in the rocks, here and there interrupted but extending for many miles, and in some instances stretching across the entire State.

The outcrops of those ore beds being so very numerous, I cannot do more than indicate the various ranges and the localities where the ores are best developed.

But as there are also many places from which I have seen very fine ores, which require fuller investigation as to quantities, I will mention the locality, in the hope that this may lead to important discoveries. For the sake of convenience, I will commence with the most eastern locality, and take up the different nearly parallel beds in succession, up to the Tennessee line.

One mile east of Gaston, near the Roanoke River, there occurs a granular variety of hematite, more or less mixed with red and yellow ochre. The ore is apparently of very fine quality, but nothing is known as to whether it exists in quantities or not; if found in abundance, its location would make it valuable.

A large deposit of brown hematite occurs in the slate formation connected with quartzites, four miles west of Smithfield, Johnson County, and a bluff of limonite is exposed at Whitacker's, seven or eight miles south-west of Raleigh, in argillaceous and chloritic slates.

The various iron ore deposits of Chatham and Moore Counties are of much greater importance.

At Buckhorn, on the Cape Fear River, a large bed of granular magnetite has been developed, from which, if I am correctly informed, about 6000 tons of very superior iron have been produced. The bed is between 20 and 30 feet thick, and lies almost horizontally between micaschist. This magnetite is associated and largely intermixed with manganesian garnet, which serves as a flux, and renders it very easy to smelt. The iron was used during the war for car-wheels, and was of such excellent quality that one of the wheels, coming accidentally into the possession of a firm in Wilmington, Del., induced them to purchase the property, with a view to establish similar works in North Carolina. The beds dip slightly to the south-east, and appear to extend in this direction, and also to the south side of Cape Fear River.

A number of beds of hematite or specular iron make their appearance in Chatham County, in the argillaceo-talcose slates; the ores are the compact and granular hematite, of reddish, greyish and iron-black color, sometimes laminated, foliated and micaceous.

In Moore County, 12 miles east of Carthage, near Governor's Creek, there occurs a pure massive kidney-shaped hematite, without admixture, probably the south-west continuation of one of the Chatham ore beds.

On Ore Hill, in Chatham County, not only red hematites are found, but also large beds of brown hematite or limonite. This hill is between 200 and 300 feet high, and perhaps two or more large veins of about 10 to 15 feet in thickness, intersect the hill in an E. and W. direction.

The limonites are of fine quality, but their appearance and geological position would indicate that they are merely "gossans," or decomposed pyritous ores, and the probability is that at a greater depth the unaltered sulphides will be found. Since my return from North Carolina, the Ore Hill has been sold for $150,000, and there is a prospect that the old furnace on the place will soon be rebuilt and be put into blast.

The Evans ore bed is from six to eight feet wide, and has been traced for nearly one mile; it is about four or five miles from the Gulf, and consists of red hematite, of fine quality. Kelley's ore bed and several others show the same character.

The ores which I have seen are excellent, but none of them are worked.

Beds of granular magnetic iron, of fine quality, have also been found not far distant, but none of them are developed. One, for instance, is about 2 — 3 miles north of Evans ore bed.

I cannot leave Chatham County without mentioning the peculiar ores which, many years ago, have been much speculated upon as being of immense value, I mean the so-called *Black Band* ores interstratified with the coal. There are three seams of this black band between the coal beds. One of these seams is six feet in thickness, and consists of argillaceous carbonate of iron in balls and layers.

Unfortunately, only a very small quantity of this ball ore could be selected which would be pure enough for the manufacture of iron. The *great mass* contains such an abundance of bones and teeth of saurians and fishes, that the amount of phosphoric acid in the same renders it absolutely worthless as an iron ore; the quantity of phosphoric acid is so great, that it has been proposed to apply it to the soil as a manure.

A band af red hematite, probably the continuation of one of the Chatham County beds, passes through Orange County. It is quite

prominent on a hill about $1\frac{1}{2}$ mile north-west of Chapel Hill. The surface is covered with ore, some of it almost pure sesquioxide of iron. Like Pilot Knob, in Missouri, it forms a series of quartzose bands, frequently with bands of pure ore alternating with quartz more or less mixed with ore.

North-east from it, in the same County, at Red Mountain, extensive beds of this ore have been discovered.

In Montgomery, Randolph and Alamance Counties, several iron ore beds have been found, which at a future day may become of importance.

Six or seven miles south-west of Troy, a band of hematite lies between bands of auriferous slates, bordered on one side by quartzite, on the other by slaty pyrophillite. It forms a mass of about 50′ wide, which has been traced for quarter of a mile. The bed is traversed by massive hornblende.

About four miles north of Troy a series of magnetic iron ore beds occur in the neighborhood of Carter's Gold Mines. The ore is frequently crystallized, friable, and is intermixed with talc and quartz. The continuation of some of these ore beds pass through Randolph and Alamance Counties, where they yield ores of most excellent quality, as, for instance, three or four miles south-west of Franklinville, where an abundance of fine magnetite is found on the surface in the immediate proximity of a vein, and at La Grange; at the latter place there also exist large deposits of bog iron ore.

Some of the most important developments have been made within the last two years by the North Carolina Centre Iron and Manufacturing Company, of this city, not only in the great titaniferous iron belt which passes principally through Guilford and Rockingham Counties, and extends through the edges of Forsythe and Davidson Counties, but also in numerous outcrops forming parallel ranges with this formation.

I have already mentioned the accumulation of iron ore in the gneissoid rocks of the Greensboro' Belt.

The ore forms one or more strata between the rocks, and their extent has been proved for about 30 miles. Near the north-eastern extension the ore beds present a remarkable character, as proved by Prof. J. P. Lesley. He has shown the beds to be outcrops of the same synclinal basin, the so-called Tuscarora range being the south-east outcrop, with a north-west dip, while the so-called Shaw range is the north-west outcrop, with a south-east dip. The ore is a granular

magnetite, more or less mixed with a micacceous mineral, also with hematite or menaccanite, and in some places it is associated with granular corundum or emery.

The average yield of the ore is 55 per ct. of iron; it contains, as I have already mentioned, small quantities of chrome, cobalt and manganese, and on an average about 13 per ct. of titanic acid, equal to 8 per ct. of titanium.

This titanic acid is not chemically combined with all the ore: in some of the varieties I have succeeded in separating, by the magnet, ore which was almost free from it, leaving the not magnetic menaccanite behind.

During the war, it was worked in bloomeries on a small scale, about two miles from Friendship, Guilford County, on a place which is now called Tuscarora, and has produced a quality of iron which was very remarkable for its toughness, its great strength and adaptation for the manufacture of steel.

Almost in range with these ore beds, magnetites as well as titaniferous iron ores have been found at several places in Mecklenburg County: the first, eight or nine miles from Charlotte, of Steel Creek Church; also, about seven miles from the same town, on the York road; and the titaniferous ore near the old Harris mine, 12 miles south-east of Charlotte. It cannot at present be ascertained whether these ores are connected with those of Guilford County.

Before I proceed with the consideration of the numerous iron ore beds of the slates of the Kings' Mountain group, I will mention that north-west of the titaniferous iron ore ranges of Rockingham, Guilford, etc., Counties, at least three ranges have lately been found between it and the Dan River, called the Johnny Watson, Love and McQuillan ranges. No developments have been made as yet, but the analyses of some of the ores show them to be free from titanic acid, and yielding about 50 per ct. of iron.

A very extensive and important belt of iron ores, which has furnished the greater portion of the iron used in the State, occurs in the slates of the King's Mountain group. It consists of a series of parallel magnetite ore beds extending, with frequent interruptions, from the neighborhood of Danbury in Stokes County, across the entire State into South Carolina.

The character of this series of magnetite beds is so uniform that it would be tedious to enumerate all the important beds; I will therefore point out only a few of the most characteristic ones.

The ores are granular magnetites *without titanic acid*, at times quite pure, but generally in part altered into hematite, and more or less intermixed with fine grained actinolite, tremolite, talc or chlorite and frequently associated with small quantities of epidote. The average of the ore is above 60 per cent.

A very fine bed of this granular magnetite associated with actinolite is the Rogers ore bank, near Danbury in Stokes County, which has been worked for a long time, and the ore smelted at the furnace on the Dan river.

There are several parallel ore beds; the upper is of the finest quality and most valuable. It is between seven and twenty feet in width, yielding on an average about 60 per cent. of iron. The ore is almost free from phosphorus and sulphur. Some of the smaller beds at their outcrop are rather sulphurous. Similar very fine beds occur in Surry County; the ores are schistose granular magnetites, with talcose, micaceous and quartzose admixtures.

At Tom's Creek this ore has been worked since 1795, and bloomeries are now in operation. Other ore beds, which also have been extensively worked, are the Williams' Ore Bed and the Hyatt's Mine.

The southern continuation of the ore beds of Stokes and Surry are developed again in Forsythe and Yadkin Counties. The character of the granular magnetites remains the same, and is an association of talc or actinolite. They have been extensively worked at Hobson's in Yadkin County, near the east bend of tha Yadkin River and other places.

Probably the beds in Davie County, on the South Yadkin River, are the same, and pass through Iredell County near Statesville into Catawba and Lincoln Counties, where they have again been extensively worked for a long time in blast furnaces, as well as in bloomeries, producing iron of great strength and toughness.

In Gaston County the same beds of granular magnetite, to a great extent altered into hematite, with a fine grained actinolite slate, have been worked on the High Shoal property on the Little Catawba River, at Ellison's and Carson's Ore Banks.

Not only magnetites furnish the material for the production of iron, but also very fine limonites, fibrous, cavernous and partly resulting from the alteration of carbonate of iron, often yet showing its crystalline structure. They occur in large veins or beds in the slates; as they result mostly from the oxidation of pyritous ores, it

may be expected that at a greater depth this will replace them entirely. The Orman and Mine Mountain and Ferguson Ore Banks, all on the High Shoal property, have been extensively worked. It is to be regretted that litigations have thus far prevented Admiral Wilkes from commencing operations at this highly valuable property, with its magnificent water power and other facilities for conducting a large manufacturing business. Near the top of Crowder's Mountain a vein of specular iron has been found. In the vicinity of King's Mountain the magnetic ores have been worked since the latter part of the eighteenth century. One of the ore beds is about forty feet thick. Besides the magnetites there are also limonites of good quality. A very striking feature of this very important and extensive belt of magnetites is its proximity to a parallel band of limestone, which accompanies the iron ore at almost every locality from Danbury down to King's Mountain.

Entering again the gneissoid rocks, we meet near Newton in Catawba County a very valuable bed of granular magnetic iron in syenite, resembling the ore from Cranberry in Mitchell County.

Magnetites as well as hematites are found in Wilkes and Caldwell Counties, some of which were formerly manufactured into iron. One very promising outcrop of large beds of fine granular *titaniferous* magnetite, for instance, has been observed near the Yadkin River, one mile west of Patterson, and another two miles north of Hickory, both in Caldwell County. At the latter place there also occurs red hematites and limonites in large deposits and of excellent quality. It is probable that further developments may prove the existence of a more extensive range, since similar granular magnetites have been found near Morgantown, almost in a line with the strike with the more northern beds.

Another bed accompanies the limestone of McDowell county on both sides of the North Fork of the Catawba River; the ores are limonite sometimes also hematite mixed with magnetite. These limonite beds continue to the west of the Blue Ridge, where we find them again overlying the limestone in Henderson and Transylvania Counties.

Several beds of limonite and occasionally hematite of good quality, exist in several localities of Buncombe county, so at Ore Mountain, two miles south west of Swannanoa Gap, and also 4—5 miles west of Ashville.

The magnetites and hematites west of the Blue Ridge deserve the

highest attention, as they are not only of very superior quality, but also found in inexhaustible quantities. The most northern bed of magnetites is found in Ashe County at the North Fork of New River, near Hilton Creek. The ore is granular and talcose, in its general character almost identical with the ores of the King's Mountain range, being granular magnetites of somewhat slaty structure from the intermixture of small quantities of talc. The ores have been worked in bloomeries and have yielded a good quality of iron.

A very superior ore occurs at Cook's Gap in Watauga County. It consists of an almost pure stratified red hematite with octahedral crystals of magnetite disseminated through the mass. It is associated with limonite. It is an ore worthy of fuller investigation.

A number of iron ore beds are found in Mitchell County; the most valuable deposits are about one and a half miles south of Cranberry, near the Tennessee line. The ore beds have not been sufficiently explored to show their geological character and size, but they appear to be inclosed between hornblende slates and a peculiar micaceous slate.

The size of the ore beds must be enormous; judging from the outcrops it may have a width of 300—400 yards, and extends for more than half a mile; the whole side of the hill is covered with large blocks of the finest quality of magnetite, which evidently exists there in inexhaustible quantities.

The magnetite is often quite pure and polaric, coarse-grained, sometimes crystallized in octahedra, and associated with pyroxene and epidote. The pyroxene weathers into a brown ferruginous clay, in which are inclosed grains of magnetite. As these ores are soft and require little labor, they are the *only* ones worked and converted into blooms, at the works about two miles distant. The whole production is not over one ton of blooms a day. The finest quality is not touched. The analysis of a specimen representing about the average character of the ore, showed it to be entirely free from sulphur and phosphorus, and containing ·65 per cent. of iron.

There are several promising outcrops of magnetic ore beds in Mitchell County, but most of the other ores are menaccanite, which occurs at the following localities: at Crab Orchard, Cane Creek and Flat Rock.

In Madison County, on the east Fork of the Big Laurel, a large ourcrop of slaty fine grained granular magnetites, of apparently very good quality occurs, also a highly titaniferous menaccanite, containing

nearly 38 per cent. of titantic acid. A bed of specular iron exists at Jewell Hill.

Other beds of magnetic ores in the same county occur in hornblende slates near Fines Creek in Haywood, and in garnetiferous micaschist at several points in Macon County.

I have yet to mention the immense beds of limonite or brown hematite, which occur in several localities in Cherokee County, associated with the limestone or marble and talc, one of which is worked, about one mile from Murphy.

The ore is of very fine quality, compact, also porous and fibrous. in some places ochreous: the quantity is inexhaustible, and beyond doubt the region where these deposits exists will sooner or later become a large iron manufacturing district.

Coal. The great abundance of iron ores in North Carolina requires for their reduction a large amount of fuel, and the question of its supply has for a time given a great deal of anxiety to those who are most largely interested in the manufacture of iron, as under the present system of forest destruction, instead of cultivation, the manufacture of charcoal iron must eventually be abandoned, although this may not take place for hundreds of years yet to come. It is therefore of the greatest importance that North Carolina contains several kinds of coal, some of which are of excellent quality, and in the immediate neighborhood or within a short distance only of the most valuable iron ore deposits.

I have already stated that the North Carolina coal does not belong to the so-called carboniferous period, but to the triassic; it is of the same age as the coal near Richmond, Va.

In Chatham and Moore Counties is the south-eastern extension, generally called the Deep River Coal Field; in Rockingham and Stokes Counties the north-western of the same beds, or the Dan River Coal Field. The centre is washed away.

From the investigations of Prof. Emmons and Admiral Wilkes, we learn that the Deep River coal is of the best quality, well adapted for the manufacture of iron and gas, and can be obtained in inexhaustible quantities.

The area underlaid by coal is over forty square miles, containing over 6,000,000 tons of coal to each square mile. The coal measures consist of strata of slates, calcareous shales, alternating with beds of argillaceous carbonate of iron and seams of coal, all inclosed between two beds of red sandstone.

Five seams of coal have been observed; the upper consists of a bed of six and a half feet in thickness, separated by a seam of black band. Near the outcrop it is somewhat contaminated with sulphur, which diminishes, however, as the depth increases. There are several varieties of coal, the highly bituminous and semi-bituminous; near a trapdyke it has lost almost the whole of its volatile matter and has become an anthracite. According to an analysis of coal from the deep pit at Egypt, by Dr. Jackson, it contains:

Fixed Carbon	=	63·6
Vol. Matter	=	34·8
Ash	=	1·0

An analysis of Egypt coal, which I have lately made, gave:

Moisture	=	0·84
Vol. Matter	=	25·75
Fixed Carbon	=	63·27
Ash	=	10·14
		100.00 per cent.

It contained 1·35 per cent. of sulphur.

An analysis of coal from the Gulf gave me:

Moisture	=	1·16
Vol. Matter	=	21·90
Fixed Carbon	=	70·48
Ash	=	6·46
		100.00 per cent.

Sulphur only 1·02 per cent.

All these analyses show the great value of the Deep River coal.

The Dan River coal field embraces an area of over thirty square miles; it has hardly been developed. Small quantities have been mined near Madison, Rockingham County, which were used by the blacksmith in the neighborhood; and the North Carolina Centre Iron and Manufacturing Co., of this city, has made a few trial pits which have proved the existence of five beds of coal, although it is probable that there are others besides.

The coals which I have examined from two of the seams near the outcrop gave respectively, 11·44—13·56 per cent of ash, 75·96 and 76·56 per cent. of fixed carbon and about 12 per cent. of volatile matter. These results are very encouraging. The Dan River coal field being the north-west continuation of the Deep River, has probably the same seams, and, where the coal is undisturbed, the same quality of coal. These coal fields are not only of general value, but, when it is re-

membered that they lie in close proximity to some of the largest and best iron beds in the State, their importance can then be fully appreciated.

Diamond and Graphite. North Carolina possesses carbon, not only in the form of several varieties of coal, but also in its two other modifications, as diamond and graphite.

Both occur in the old gneissoid rocks, the graphite in beds interstratified with the micaschist or gneiss; the diamond in the débris of such rocks, associated with gold, zircon, garnet, monazite and other minerals.

It is very remarkable that these two minerals are found in strata of the same age; and this fact reminds me of an analogous one, which may throw some light on their origin, viz., in producing the adamantine boron we always obtain the graphitic form at the same time.

Diamond has not been observed in North Carolina in any more recent strata, and in the itacolumite regions *no* diamonds have ever been found, as in Brazil; from which it appears that the itacolumite of Brazil is either simply a quartzose micaslate of similar age with the North Carolina gneissoid rocks, or that, if it is cotemporary with the North Carolina itacolumite, the diamonds were not *produced* in the same but came from older rocks, and were re-deposited with the sands resulting from their reduction to powder and are now found imbedded in the same, their hardness having preventing their destruction. Seven or eight diamonds have thus far been found. They occur distributed over a wide area of surface in the counties of Burke, Rutherford, Lincoln, Mecklenburg and Franklin, and I have no doubt, if a regular search would be made for them, they would be found more frequently. Some of the stones were fine crystals of first water; their weight was from one half karat to about two karats.

Graphite, so much in demand now for the manufacture of crucibles for melting steel and other metals, for lead pencils, as an anti-friction agent, for stove blacking, paint, &c., is found in numerous localities in the State.

The largest beds known since nearly half a century occur a few miles west of Raleigh in Wake County. There appear to be two belts about half a mile apart; the beds contain several seams of greater purity from six to eighteen inches in width. The beds are known to extend for a distance of eighteen or twenty miles.

It has been explored seven miles north-west of Raleigh, and a shaft

has been sunk to a depth of one hundred feet. It is mostly mixed with fine grit and is rather slaty, and would require mechanical means for the separation of the impurities. Other beds of graphite, but not so extensive, are found in Lincoln, Caldwell, near Hickory, and in Burke Counties near Morgantown. None of them are developed. The best quality which I have seen came from Alexander County, three miles from Taylor's, and from Cane Creek in Person County.

Sulphur is not found in North Carolina, except occasionally in small crystals, in cavities of quartz, resulting from the decomposition of pyrite. A large supply of sulphur ores will be furnished when the mines of the State are worked to a greater depth. One large vein of pure iron pyrites occurs in Gaston County. Most of the other veins will furnish in addition gold and copper.

Corundum.—Corundum, which, on account of its hardness, is so much sought for as a cutting and polishing material for hard substances, has been found, in a state of great purity and abundance, at several places in the neighborhood of Franklin, in Macon County, in connection with granites and chrysolite rocks.

It is mostly greyish or brownish, but sometimes it assumes a beautiful sapphire blue and ruby color. It is to be regretted that the blue has not yet been found in pieces large enough to be cut for gems, and that the ruby has not the requisite trasparency. A large boulder of dark blue corundum was found, many years ago, near the French Broad River, in Madison County. It has lately been observed on the Burnsville Road, 19 miles from Ashville. In small quantities it is found at Crowder's and Clubb Mountains, Gaston County.

The granular corundrum or emery is associated with the magnetites of the great titaniferous iron range in Guilford County.

Rutile.—Titanic acid, in the form of rutile, used in the arts to give a peculiar color to artificial teeth, is found in considerable quantity at Crowder's and Clubb Mountains, in Gaston County; also at several localities in Mecklenburg and Mitchell Counties.

Mica, Feldspar, Kaoline, Pyrophyllite.—Hundreds of years ago, long before the Indians occupied the territory of North Carolina, many excavations were made in the numerous large coarse-grained granite beds of Mitchell, Yancey, Cleveland and other Counties. In the year 1867 a number of these old mines have been taken up again, and now mining, on a somewhat extensive scale, is going on, and a

great portion of the mica used in the arts for stoves, lamp-shades, window-panes, etc., comes from Mitchell and Yancey Counties, North Carolina. The mica has mostly a slightly brownish color; it occurs, irregularly distributed, through the granite, in rounded pieces, some of them weighing several hundred pounds. It is then split and cut into marketable shapes, which, according to size, will sell from $1 — $10 per pound.

The same localities furnish a very fine quality of orthoclase or potash feldspar, used for glazing porcelain and for artificial teeth.

At some of the mines in Mitchell County the orthoclase is almost completely decomposed, and leaves frequently a snow-white kaoline or porcelain clay. It is found at several other localities, as in Lincoln, Burke and Macon Counties.

In the region of the Deep River, in Chatham and Moore Counties, very extensive beds of pyrophyllite slate have been worked for a long time.

It is sometimes called agalmatolite, from the fact that from a dense variety of the same rock the Chinese cut and carve their little images, idols and toys. The North Carolina mineral, being entirely free from grit, is largely used as an antifriction material, also for the lining of furnaces, slate-pencils, in the manufacture of wall-paper, as a cosmetic, and for other purposes. Other, though less extensive, beds have been found in Montgomery and Gaston Counties.

Serpentine, Talc.—Only one locality has come to my notice from where a serpentine could be obtained fit for ornamental purposes. It has a dark greenish-black color, contains very small seams of a greenish chrysolite, with silky lustre, and acquires a good polish. Found in large quantities 1½ mile below Patterson, in Caldwell County.

The serpentine found in the chrysolite beds west of the Blue Ridge are of no value.

The most beautiful white, or greenish-white massive, or finely crystallized talc is found, in inexhaustible beds, in many places in Cherokee County.

It is used for similar purposes as the slaty pyrophyllite of Chatham and Moore Counties. Massive and schistose talc, or soapstone, suitable for fire-places, mantle-pieces, stove-linings, etc., is found in many localities in the State.

Barytes.—This material, when quite white much used as a paint, and more generally for the adulteration of "*white lead*," is found in

abundance and excellent quality at several localities. A coarsely granular variety, white, like marble, is found in Union County; another similar one, massive and granular, in a vein from 7 to 8 feet in thickness, in Gaston County, at Crowder's Mountain; and a greyish-white laminated variety, at the Latta mine, near Hillsboro', in Orange County. West of the Blue Ridge it is found, in white granular masses, at Chandlers', nine miles below Marshall, in Madison County.

Alum and Copperas.—Many of the gneissoid slates of Cleveland, Rutherford and other Counties contain large quantities of pyrite finely disseminated through them, which, by oxidation, or weathering, produces copperas and alum, both of which were therefrom manufactured on a large scale during the war.

Marble.—Only in one or two localities in the limestones of Stokes and Catawba Counties, a fine-grained variety is found, which would be useful for ornamental purposes if the quantities were not too limited. West of the Blue Ridge, however, in Cherokee and Macon Counties, it is found in large beds, of the finest qualities. There is not only the fine-grained white, resembling that of Carrara, but also the greyish-veined marble, like the Italian, and a most beautiful variety of a fine pink hue.

The limits of this paper are already far beyond my original expectations; and still I might add many more details which would be of interest. In as concise a form as possible, I have indicated and described the principal valuable minerals in the State, and the localities where they occur. I have dwelt rather more fully upon gold, copper, iron and coal, because of their greater importance, especially the two latter, which I believe will prove a source of immense wealth to the State.

My various visits to North Carolina, and more particularly the opportunities afforded me for observations during my trip there last summer, have enabled me to collect many facts and much data relative to the various mines and mining districts, which doubtless would be of interest, but which want of space compels me to omit for the present. I hope, however, that at some future day it will again be my privilege to present the Franklin Institute with further observations on this interesting subject.

Philadelphia, December, 1871.

THE CHEMICAL THEORY OF THE VOLTAIC BATTERY.

By J. P. Cooke, Jr.

(Continued from page 412.)

ELECTRICITY.

17. *Characteristics of Electrical Polarity.*—The familiar phenomena of electricity are the manifestations of a polar condition of matter, which, in several respects, is closely allied to magnetic polarity. Thus electrical polarity determines effects of attraction and repulsion similar to those produced by a magnet, although the force exerted is far more feeble. So also electrified bodies—that is bodies electrically polarized—induce a similar condition in all neighboring and susceptible masses of matter, and the phenomena of electrical induction closely resemble those of magnetic induction. There are, however, two distinctive features of electrical polarity, which appear more or less in all electrical phenomena, and determine most marked differences between electrical induction and the corresponding phases of magnetic polarity.

In the first place, a ready susceptibility to electrical polarity is, as far as we know, a universal attribute of matter, and not limited, like magnetism, to a few substances. All bodies are *electrics* (that is, susceptible of electrical polarity) to a greater or less degree, and the difference between what we familiarly call conductors and non-conductors of electricity is similar to the difference between soft iron and steel, in their relations to magnetism. When we electrify a mass of glass or resin the body under favorable conditions retains its polarity for a short time, but on a mass of brass we cannot excite even a transient polarity, unless the body is insulated from all surrounding conductors by some non-conducting support. Otherwise the polarity almost instantly spreads through the contiguous conductors, and the body becomes thus reduced to the state of the great mass of the earth, which everywhere acts as a general leveler of electrical polarity.

In the second place, electrical polarity may not only be imparted to neighboring bodies by induction, when, as in magnetic induction, the inducing body sustains no loss of energy; but it may also be transferred from one insulated conductor to another by contact; the gain of the one body being attended with a corresponding loss to the other, as the word transfer implies.

18. *Theory.*—All phenomena of electrical transfer forcibly suggest the inference that electrical polarity is not an affection of the molecules themselves, but of an atmosphere surrounding the mole-

cules, which is capable of separation and hence of transfer. This polarized material appears to be a highly elastic medium, co-existing with the luminiferous ether in the molecular atmospheres, and without attaching to the words any more definite meaning than this, we may call the material in question the *electrical fluid or ether*, and speak of electricity as a highly attenuated form of matter, to which the terms relating to quantity are strictly applicable. According to the view then here adopted, electrical phenomena are manifestations of the polar condition of a medium, which envelopes the molecules of all known substances, and the vitreous and resinous, or positive and negative, electricities of the old theory are two of the constituents of this atmosphere, which, as we suppose, is held about the molecules just as the air is retained upon the earth. It is also supposed that in the normal state there are present in the atmosphere of every molecule, definite proportions of these two constituents (or perhaps merely opposite conditions) of the ether perfectly intermingled, but that by various causes a more or less complete separation of the two may result, determining the phenomena of electrical polarity. Again, without attempting to explain the nature of the difference between these two inconvertible etherial substances (or states of the same material) we recognize the existence of a strong tendency to a perfect blending of these elements of the ether as the cause of the phenomena of electrical currents. Further, our theory assumes that the blending of the two opposite electricities is a phenomenon of the same class as that of the diffusion of gases, only taking place with vastly greater rapidity on account of the very great elasticity of the etherial medium. Lastly, it assumes that the atmospheres are held around the molecules by a molecular attraction, which is capable of coping with their enormous elasticity, and that while these atmospheres merge in the general etherial medium in which molecule and planet alike float, the electrical elements of the ether, being more readily compressible than the luminiferous constituent, are limited to the neighborhood of the ponderable molecules, around which they are condensed.

19. *Electrical Conduction and Induction.*—The distinctive characters of electrical polarity we have pointed out, explained by the theory of the last section, indicate clearly the nature of the difference between the polar phenomena, which appear in electricity and magnetism. Thus, while the magnetic condition simply spreads through a mass of magnetic material, placed in contact with a magnet, we recognize in the corresponding electrical phenomenon, which we call an electrical

current, not only this molecular induction, but also an actual transfer of what we call electricity from molecule to molecule through the long line of conductors, and the whole order of the phenomenon reminds us of a flowing fluid. So also while in magnetic induction the intervening material or diamagnetic appears to be wholly passive, we find that in electrical induction the dielectric under the same conditions is strongly polarized.

Indeed, Faraday supposed that in all cases of electrical induction, the polar condition spreads from one conductor to the other through the intervening molecules of the insulator, which he called the *dielectric*, and, if so, this mode of electrical action does not differ essentially from the spreading of magnetism through a rod of iron, and is simply the condition antecedent to that transfer of the electric fluid, which distinguishes the electrical current. And although it may be an open question whether the polarity of the dielectric is an essential condition or only an incidental effect of the polarity induced in the associated conductor, it must be admitted that, in all known cases of electrical induction, the intervening molecules of the dielectric are unquestionably polarized, as must necessarilly be the case, seeing that all matter is electrically susceptible, and that the circumstances of the phenomena are exactly those which Faraday's theory would require.

20. *Statical Charge of Electricity.*—In magnetism the polarized material appears to be inseparable from the molecule, and, in consequence, each molecule is a perfect magnet, having its opposite polarities exactly balanced, and capable, therefore, of returning to the neutral condition by itself alone when these parts react on each other. It is very different with electricity. Here the transfer of the polarized ether from molecule to molecule may lead to the accumulation, at determinate points, of one or the other of the two polarized states of the electrical ether, and hence disturb the polar-equilibrium of the molecule. Thus these two opposite conditions of the ether, which we call respectively vitreous and resinous, or positive and negative, electricities may be to a greater or less degree isolated, and a body is said to be *charged with vitreous or resinous electricity*, when one or the other preponderates in the atmospheres of its molecules taken as a whole.

As might be expected, therefore, the ordinary type of electrical polarity differs widely from that of magnetic polarity, and involves at least three different bodies, viz., two conductors and an intervening

dielectric. As the type of magnetic polarity was represented by Fig. 4, repeated below (Fig. 14) for the sake of comparison, so the ordinary type of electrical polarity, as manifested in the so-called statical phenomena of electricity, may be represented by the diagram of Fig. 13. Here C and C′ are the surfaces of two conducting bodies insulated from each other by the dielectric D. In the body C, we will assume there is an excess of vitreous or positive electricity, which for the reason we shall soon see, is accumulated on the molecules at or near the surface, and in C′, there is an exactly equivalent excess of resinous electricity distributed in a similar way, while between them we have the polarized molecules of the dielectric.

Fig. 13.

Electrical Polarity.

Fig. 14.

Magnetic Polarity.

If the dielectric admitted of no transfer of the electric fluid between the two conductors, the condition above represented would be as permanent as is the polarity of a magnet. But this is not the case with any dielectric known, and there is always a more or less rapid transfer of the electric ether from molecule to molecule, through the insulating material until the opposite polarities are neutralized, and the whole system restored to the normal condition. In other words every insulator is a conductor to a limited extent, and the transfer of electricity through the material of the dielectric is simply a slow electrical current. Moreover it will be noticed that a charge of electricity necessarily implies an equal and opposite charge on some neighboring conductor or conductors, and that the polar condition of the intervening dielectric depends on the opposition of these charges, for so great is the mobility of the electrical ether that electrical polarity cannot, like magnetic polarity, persist for an instant on a conductor, after the inducing cause ceases to act.

21. *Current of Electricity.*—The lines of material molecules, through which a transfer of the electrical ether is taking place, as between C and C′ in Fig. 13, form the channel of what we call an electrical current. An electrical current is frequently compared to the flowing of water through a pipe, and the conditions, which regulate the amount of flow, are so similar in the two cases that the anal-

ogy is of great value in rendering the more obscure phenomena intelligible. It must be remembered, however, that an electrical current is not the continuous motion of a mass of matter in a single direction, but the reciprocal transfer of the electrical ether between the molecules of the conductor, the two electricties passing in opposite directions at the same time; so that while one-half of the whole charge at C in Fig. 13 passes to C′, one-half of the whole of the charge at C′ passes to C. This transfer implies, as we shall hereafter see, an oscillation of the molecules of the conductor, which determines a wave motion throughout its whole extent, and some of the most important effects of the current may be referred to this mechanical action. It will be best, however, to defer the further discussion of the subject until we have applied our theory as already developed, to the explanation of some of the more familiar facts of statical electricity.

22. *Attraction and Repulsion.*—The very word electricity derived from the Greek name for amber (ἤλεκτρον) suggests, as the first object of inquiry, one of the most familiar manifestations of electrical energy, indeed the only phenomenon of the class known to the ancients, and still a fundamental fact of the science. When a piece of amber of any other resinous substance is rubbed against a woolen surface, it acquires the property of attracting light bits of straw or paper. The experiment is now usually made with a common stick of sealing wax rubbed against the coat sleeve; but, for class illustrations, it is best to employ a large baton of the same material, easily made by casting the wax over a paste board core,* while a skin of cat's fur, which can be obtained from a furrier, makes an excellent rubber. The baton is held in one hand, and, when excited by friction against the fur held in the other, is then brought near some small balls made of alder pith. These are first attracted and afterwards repelled, and then alternately attracted and repelled, producing a very lively action as represented in Fig. 15. In order to illustrate still more fully the principles involved in this familiar experiment, it is best to provide further: 1, a metallic sphere about six inches in diameter,

Fig. 15.

* A cylinder of card board covered with thin sheet gutta percha is an admirable substitute for the baton of sealing wax.

mounted on an insulating stand; 2, a glass tube about two inches in diameter by three feet long, together with a silk pad—coated with the usual amalgam—for rubbing it; and 3, two toy balloons of india rubber, which should be fastened by short silk threads to moveable blocks of wood, resting on the table so that the balloons shall float on a level with the spherical conductor, see Fig. 16.

Fig. 16.

If, now, we stroke the balloons with the cat's fur they will soon become highly electrified, both necessarily in the same mode, and on bringing them together they will repel each other. If next we electrify the sealing wax by rubbing with the fur, it will be seen, on bringing the baton near the balloons, that they are both repelled by it, but on the other hand the glass tube, after being electrified by friction against the amalgamated silk, will be found to attract them with equal strength. Again repeating these experiments, but insulating the rubber in either case, by interposing a sheet of gutta percha between it and the hand, and using india-rubber gloves as a still further protection, it will appear that the fur or the amalgamated silk are electrified as strongly as the resin or the glass, but that they act on the balloons in just the opposite way. Thus, while the sealing wax will repel the balloons, the fur with which it has been rubbed will attract them; so also while the glass tube attracts them the silk pad repels them.

Electrical excitement may be produced by friction with a great variety of materials, and under a great variety of conditions, but in all cases delicate experimenting will show that the two bodies associated become oppositely polarized, as in the above experiment. Moreover it is by no means essential that the materials rubbed together should be non-conductors, like glass, silk, resin and fur. Only if a conductor is used, the effect cannot be made evident unless the body is insulated. To illustrate this point, we may next stroke with the cat's fur the insulated metallic ball, which has been provided for the experiment. It will soon become highly electrified, and the polar condition may be made evident by bringing it near one of the balloons,

which will be decidedly repelled. If, however, we touch the ball with the finger, even in one place, all indications of electricity will instantly disappear, although the charge could not be wholly removed from the resin or the glass, except by passing the hand over the entire surface. Electrifying now the resin, and passing the baton over the metallic ball so that the metal may touch the resin at many points, it will be found that the baton has in part lost, and the ball acquired the power of repelling the balloons. Next, after discharging the ball with the finger, repeat the experiment, but use the glass tube in place of the baton, and notice that the ball now attracts the balloon, which it before repelled. Lastly, having again excited the resin with the fur, pass the baton over the still electrified ball, and observe that this addition of electricity, instead of increasing rapidly, lessens the attractive force until at last it wholly vanishes, when it will be found that the body has been restored to its normal state.

(To be continued.)

CYCLICAL RAINFALLS AT LISBON.

By Pliny Earle Chase, Professor of Physics in Haverford College.

Read before the American Philosophical Society, Aug. 18, 1871.

The more strongly marked and decisive character of the curves of lunar monthly rainfall in Philadelphia than in Great Britain (Proc. A. P. S., v. x, pp. 523–34), rendered me desirous of obtaining observations from some European station in lower latitude. The intimation of that desire to the Director of the "Observatorio do Infante Dom Luiz," at Lisbon, was promptly followed by the transmission of a copy of observations extending over a period of sixteen years, which is herewith presented. I also submit some of the tabulated results of such discussion of the observations as I have already undertaken, which appear to me to corroborate, in a most satisfactory manner, the views I have hitherto advanced respecting the meteorological influence of the moon. Some of the tables also afford interesting indications of a somewhat similar planetary influence, sufficient, as it seems to me, to encourage further investigation.

One of the objections most often urged against the acknowledgment of any appreciable lunar or planetary influence upon rainfall or other atmospheric phenomena, is based on the different, and sometimes contradictory, results obtained by different investigators, from observations in different places and at different times; another arises

from the difficulty of conceiving any tidal or other force adequate for the production of any considerable disturbance. Nevertheless, such of the objectors as are familiar with Howard's discussion of the moon's influence upon the barometer; Sabine's, of lunar disturbances of terrestrial magnetism; or Schwabe's and Wolf's, of the dependence of sun-spots upon planetary configurations, seem to admit—at least I am not aware that any of them deny—the probability of the conclusions which those eminent observers have severally expressed.

If it is conceivable that Saturn, Jupiter and Venus can in any way affect the cloudiness, or amount of spotted surface of the sun, notwithstanding the immense preponderance of his attractive, magnetic and other supposable forces, it is surely much more easily to imagine that they may similarly affect the meteorological phenomena of the earth, which opposes an antagonizing mass only $\frac{1}{326800}$ (according to Newcomb's estimate) as great as that of the sun. If the lunar tides of our atmosphere are of sufficient magnitude to affect the barometer, the consequent waves must effect a blending of aerial currents of different temperatures and different degrees of humidity; and in consequence of the stratification of the upper and lower winds, this blending offers a unique opportunity for the practical study of the opposite tidal tendencies in deep and shallow fluid seas or envelopes. If the lunar are as unmistakable as the solar modifications of magnetic phenomena, the analogies which have been pointed out by Messrs. Baxendell and Bloxam between magnetic and pluvial, and by myself between pluvial and auroral curves, are indicative of other possible lunar influences which are equally unmistakable. If the difficulty of conceiving an adequate cause for a supposed phenomenon were to deter us from inquiring whether an apparent dependence were real or illusory, all progress in science would become impossible. Finally, if it can be shown that solar rain-curves exhibit different, and often contradictory inflections, similar to those which are objected to in the lunar curves, and if a consistency of disagreement can be shown between the lunar results at two given stations, accompanied by a consistency of agreement between the results in different cycles at the same station, the argument from apparent contradiction will be deprived of all its force.

I have no hope of thoroughly convincing any one who is skeptical of lunar influence on the weather, by deductions from observations at one or two, or a half dozen stations, but I believe that any one who will examine, carefully and impartially, the tables I have already

published, based on observations in India, Great Britain, Portugal, Canada and different portions of the United States, will at least be willing to admit that the question is an open one. And if he will compare my previous tabulations with those which accompany the present paper, he may, perhaps, find any lingering skepticism shaken, however prejudiced or inveterate it may be.

For convenience of comparison, I represent, in each instance, the mean rainfall for the entire period under consideration by 100, and any deviation from the mean, whether of excess or deficiency, is denoted by the addition or subtraction of a corresponding percentage. The smoothing by successive means is uniform in all the tables. I invite special attention to the columns of lunar rainfall at Lisbon, in each of the first two tables, representing two different sets of three independent periods, averaging 64 months, a cycle which I have hitherto supposed too short to yield any satisfactory results. If there is no casual nexus, it is difficult to imagine any possible reason for the striking similarity between the ordinates for the different cycles, a similarity which I think quite as striking as that between the solar curves at the same station for independent periods of similar duration. If the lunar disturbances are considered as merely tidal, while the solar are partly tidal, but principally thermal, their relative magnitudes suggest interesting comparisons between centrifugal and centripetal forces analogous to those which I have hitherto had the honor of presenting to the Society.

The resemblance between the independent curves in Table III is not very marked; but the yearly mean is curiously like the yearly averages of the lunar monthly ordinates in Tables I and II, if we construct the curves so as to compare the ordinate of Jupiter's opposition, No. 16, with the ordinate of lunar conjunction, No. 1, and *vice versâ*.

The tendency to opposition between rainfall curves on opposite sides of the Atlantic, of which I have already submitted some illustrations to the Society, is interestingly shown near the solstitial and equinoctial periods, by Table IV.* Columns 6 and 7 of the same table indicate a similarity between the curves of daily and annual rainfall at Philadelphia, which lends additional interest to my comparison of pluvial and auroral curves.

* Published by permission of Prof. Benjamin Peirce, Supt. U. S. Coast Survey.

EXPLANATION OF FIGURES.

The horizontal lines represent the average rainfall; each vertical space represents a deviation of ·2 of the mean value; each horizontal space represents two days in the abscissas of the lunar curves, or $\frac{1}{15}$ of a year in the abscissas of the solar curves. The lunar curves begin and end with the day of new moon: the solar curves with January 1.

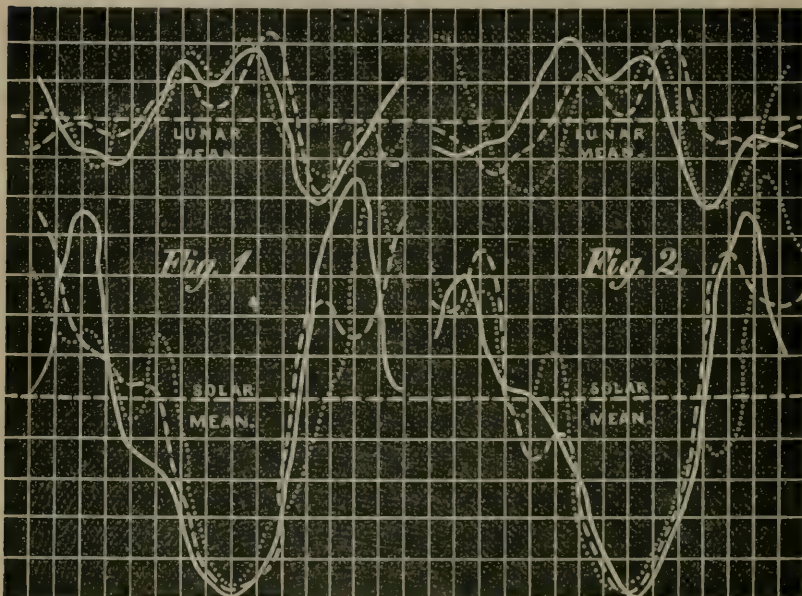


Fig. 1.—*Lunar Curves.*

December to March, inclusive; continuous line.
April to July, inclusive; broken line.
August to November, inclusive; dotted line.

Solar Curves.

1855, '58, '61, '64, '67, '70; continuous line.
1856, '59, '62, '65, '68; broken line.
1857, '60, '63, '66, '69; dotted lines.

Fig. 2.

1855–'60; continuous line.
1861–'65; broken line.
1866–'70; dotted line.

TABLE II.

Correspondent Rainfalls at Lisbon in Lunar and Solar periods.

DAY OF YR.	LUNAR MONTHLY. 1855—60 R.	N.	1861—65 R.	N.	1866—70 R.	N.	Av. N.	SOLAR YEARLY. 1855—60 R.	N.	1861—65 R.	N.	1866—70 R.	N.	Av. N.
1...	115·0	87	170·1	97	178·7	141	104	222·1	131	298·2	150	178·7	171	146
2...	116·8	85	151·2	95	154·9	144	103	235·6	148	208·5	144	118·9	155	148
3...	116·2	84	134·3	99	150·4	133	98	231·0	162	78·6	145	168·9	146	152
4...	108·4	85	117·0	83	96·6	117	91	369·9	162	290·0	162	129·2	148	158
5...	158·7	87	106·3	76	119·0	101	86	218·5	142	283·5	175	143·5	151	156
6...	124·7	87	108·0	73	84·7	86	81	103·1	119	236·7	163	204·5	150	142
7...	162·9	90	102·8	77	69·6	73	81	223·8	108	226·9	128	147·0	126	119
8...	158·2	90	172·8	83	73·4	66	85	162·3	105	51·6	89	50·0	96	97
9...	173·5	112	93·3	87	76·0	66	91	126·6	101	73·9	71	40·7	95	90
10...	162·4	126	180·3	93	73·3	69	94	209·6	97	98·6	76	134·3	118	95
11...	231·9	139	120·1	103	50·9	79	110	124·2	88	140·9	85	239·9	124	95
12...	235·5	145	193·6	117	98·1	99	123	111·8	74	163·5	79	46·2	91	80
13...	205·2	140	264·1	124	164·5	118	128	112·5	59	52·6	56	31·4	47	55
14...	216·2	128	153·6	118	102·9	125	123	75·8	40	31·1	31	5·7	21	32
15...	118·8	119	152·3	109	154·8	121	116	3·9	22	11·8	15	8·7	12	17
16...	191·4	121	193·6	105	91·3	116	114	15·8	10	7·7	7	13·9	10	9
17...	199·1	130	136·6	108	77·6	118	118	8	5	6·2	5	8·6	12	7
18...	202·7	133	165·9	119	111·7	128	127	3	7	·1	7	6·1	15	9
19...	249·2	123	246·6	135	176·8	137	131	21·2	14	1·5	15	34·5	20	16
20...	120·4	102	234·1	144	144·6	127	123	38·2	24	63·6	26	9·0	31	27
21...	101·9	81	251·9	128	113·0	99	101	48·4	40	22·0	47	36·8	51	47
22...	117·3	65	135·3	105	44·3	69	82	76·9	78	60·8	86	110·1	72	80
23...	60·8	55	92·5	91	29·4	55	69	218·4	124	261·7	136	75·8	79	116
24...	58·6	56	158·0	99	70·8	56	70	356·6	159	254·0	171	109·2	73	141
25...	87·8	70	182·3	95	78·8	59	77	215·7	179	312·1	176	8·7	79	153
26...	175·8	86	112·8	91	28·3	65	84	298·5	194	156·8	165	45·9	123	166
27...	149·2	93	143·1	90	72·4	81	89	158·0	191	238·4	156	298·7	185	177
28...	96·8	93	148·9	91	133·2	103	95	223·6	163	233·9	149	261·0	211	171
29...	180·4	92	145·5	93	129·8	148	99	134·8	130	177·9	143	165·0	200	154
30...	121·2	90	141·2	95	97·9	130	102	179·3	121	111·4	145	218·7	185	146

TABLE IV.

Comparative Daily and Yearly Rainfalls.

☉ H. OR 18 24	PHILADELPHIA. June.	Dec.	April.	Oct.	Average Daily.	Average Annual.	GREENWICH. January.	July.	April.	Oct.
1...	123	92	120	114	91	92	53	92	120	99
2...	111	78	130	112	91	89	54	103	143	126
3...	92	72	127	103	93	89	63	107	169	148
4...	77	71	118	97	98	90	66	112	179	146
5...	69	71	103	106	105	91	64	118	155	122
6...	71	73	86	105	110	94	65	129	110	98
7...	79	81	77	105	113	99	72	139	74	82
8...	84	95	78	110	113	105	74	140	60	75
9...	80	102	78	125	112	110	72	136	59	79
10...	68	96	70	140	109	113	78	133	63	85
11...	56	87	64	143	105	112	99	128	65	82
12...	55	85	67	135	102	110	127	109	66	72
13...	66	90	74	117	103	109	141	89	72	65
14...	92	100	82	93	106	111	131	94	86	66
15...	131	116	94	71	109	112	111	126	101	76
16...	172	136	111	58	108	108	97	148	115	97
17...	186	144	124	55	104	101	98	129	125	121
18...	162	133	124	56	98	95	116	88	121	133
19...	123	113	122	65	92	91	145	56	111	129
20...	98	162	125	79	87	95	170	49	90	123
21...	90	106	123	97	85	96	173	30	73	112
22...	92	119	106	106	87	96	150	32	66	98
23...	102	121	93	107	90	96	110	49	76	85
24...	118	112	101	109	91	95	72	73	98	84

TABLE I.

Different and non-correspondent Rainfalls at Lisbon, in Lunar and Solar periods, from December 1, 1854, to Dec. 1, 1870. R. Total fall; N. Normal percentage of rain.

DAY OF YR. ☉	LUNAR MONTHLY. Dec—Mar R.	N.	Apl—July R.	N.	Aug.—Nov R.	N.	Yr N.	SOLAR YEARLY. 1855+3N* R.	N.	1856+3N* R.	N.	1857+3N* R.	N.	Av. N.
1...	298·0	123	159	82	154·5	95	106	184·7	102	275·7	192	238·9	160	146
2...	223·9	115	79·7	89	113·7	104	106	120·7	121	329·7	186	112·6	143	148
3...	174·8	97	53·5	94	156·5	103	99	216·8	158	139·9	161	121·8	131	152
4...	136·9	85	36·6	97	124·4	93	90	451·3	192	170·4	138	161·4	130	158
5...	153·5	83	75·9	98	104·9	84	85	342·9	194	193·6	127	109·0	135	156
6...	189·8	81	68·3	96	66·3	78	83	257·4	164	94·0	123	192·9	133	142
7...	141·8	78	42·9	94	113·4	89	84	224·0	121	242·6	119	131·5	116	119
8...	106·7	78	88·8	93	187·1	102	89	69·5	87	102·2	112	92·2	94	97
9...	187·2	85	37·4	96	118·0	104	93	106·0	75	118·5	109	16·5	91	90
10...	182·9	95	83·1	102	168·9	98	98	130·6	70	164·3	110	147·6	114	95
11...	185·3	108	67·7	109	74·0	98	105	112·5	69	200·7	99	191·8	132	95
12...	252·0	121	83·3	116	111·7	114	118	18·9	59	33·8	75	168·8	118	80
13...	269·8	128	1·6	121	267·0	132	128	78·8	42	84·0	49	33·7	81	55
14...	271·7	124	43·0	118	87·0	133	126	11·2	23	36·8	31	64·9	49	32
15...	173·1	118	46·2	107	118·7	122	118	6·8	11	5·3	17	12·3	25	17
16...	244·7	119	73·2	105	146·9	122	117	15·8	7	16·4	9	5·2	12	9
17...	272·6	128	53·5	107	195·4	134	126	7·9	6	1·8	7	5·9	7	7
18...	260·8	135	89·5	123	204·1	141	135	6·5	7	0·0	8	0·0	12	9
19...	266·0	136	102·9	138	297·5	132	135	12·9	12	33·2	11	11·1	26	16
20...	289·8	124	97·3	145	135·5	114	124	27·6	23	2·1	22	86·1	39	27
21...	190·1	101	105·7	135	98·9	98	106	52·1	45	20·8	50	35·3	46	47
22...	94·3	75	91·7	108	163·9	87	85	93·5	83	148·6	97	35·7	54	80
23...	105·1	69	30·1	74	69·5	77	68	231·2	129	261·2	135	63·5	72	116
24...	97·2	57	12·0	58	84·0	72	62	342·7	166	223·1	150	148·0	92	141
25...	153·2	64	42·4	64	120·7	72	67	304·1	92	157·6	142	71·8	109	153
26...	112·3	70	67·7	82	65·4	77	77	408·5	212	152·3	131	140·4	135	166
27...	244·7	87	61·6	94	164·4	82	86	625·4	216	226·5	131	143·2	174	177
28...	118·7	95	79·6	94	124·2	83	91	275·6	182	101·5	134	34·4	200	171
29...	219·1	105	52·0	86	102·7	81	93	85·9	131	214·0	150	177·8	195	154
30...	211·7	118	44·5	79	71·4	84	100	177·5	104	218·6	174	143·5	177	146

* 1855, '58, '61, '64, '67, '70. 1856, '59, '62, '65, '68. 1857, '60, '63, '66, '69.

TABLE III.

Lisbon Rainfall in Synodic years of Jupiter.

SYN. YR ☉	1855—60.	1861—65.	1866—70.	Dec.—Mar.	April—July.	Aug.—Nov.	Year.
1......	141	177	45	139	70	10	117
2......	127	148	11	121	74	93	103
3......	111	101	49	87	78	90	86
4......	98	65	70	62	79	94	76
5......	89	48	99	61	78	97	76
6......	81	43	128	70	80	96	81
7......	79	43	146	78	89	102	88
8......	88	45	151	84	96	112	96
9......	110	45	150	95	97	117	103
10......	139	45	143	106	103	112	108
11......	156	41	141	105	121	121	113
12......	146	39	154	90	137	143	116
13......	119	36	165	77	133	151	112
14......	99	37	146	74	115	124	98
15......	99	37	112	83	94	81	84
16......	108	36	100	100	89	51	81
17......	109	45	114	113	101	46	88
18......	96	68	132	117	125	60	99
19......	80	98	138	121	131	79	108
20......	67	123	127	126	115	86	117
21......	53	131	101	117	91	79	99
22......	45	129	73	95	78	76	86
23......	53	134	58	79	87	91	84
24......	72	153	58	79	111	112	96
25......	84	168	60	95	127	114	107
26......	83	196	60	117	123	99	112
27......	86	200	61	128	119	93	113
28......	106	191	64	125	140	110	115
29......	132	183	61	124	90	130	120
30......	145	183	53	133	76	130	122

CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

(Continued from page 419.)

In the previous article, at p. 417, the statement of Prof. J. Le Conte, the writer of a series of highly scientific and interesting articles on the subject of binocular vision in Silliman's Journal, we inadvertently omitted. An implied necessity for convergence of the optic axes in binocular combination will be found in the quotation given below (p. 8, No. 7, Vol. II, Third Series, July, 1871), especially as it is nowhere else intimated that pictures whose identical points are more distant than the interocular distance can be united ocularly.

"Stereoscopic may be combined with the naked eye, *also beyond* the plane of the card in the manner of a stereoscope; but there are two difficulties in the way of success in this manner of combination. In the first place, in most stereoscopic pictures, identical points are farther apart than the eyes, and therefore cannot be combined beyond the pictures without the aid of lenses or prisms. In the second place, even if the pictures are not farther apart than the eyes, and may therefore be thus combined, the dissociation of the focal from the axial adjustment, as already explained in my first paper* is difficult and imperfect, and the combined picture is therefore not clear."

PSEUDOSCOPIC OR FALSE EFFECT, PRODUCED BY TRANSPOSING THE PICTURES OF A STEREOGRAPH.

If the pictures of a stereograph are transposed, then, viewed by means of an ordinary lenticular stereograph, or by the first ocular method given, or, if an ordinary stereograph without transposition of the pictures is viewed by the second ocular method, it is plain that the right eye will see the left eye picture, and the left eye the right eye picture. In this case quite a different and, in many respects, very interesting effect will be produced, that may be called an inversion of distances. Objects that would appear nearer, according to the usual arrangement of the pictures, would now appear more remote, and the more remote objects appear nearer. This is called *Pseudoscopic*, or false effect. In fig. 6, for example, if the diagrams L and R, which represent the frustum as seen by the left and right eyes respectively, were transposed, it is plain, according to statements made in the discussion of the methods for drawing of stereographs,

* Silliman's Journal II, xlvii, pp. 73, 76.

that a stereograph of a frustum of a cone with its larger base nearer the observer would be produced, for the corresponding points of the larger circles of the diagram would then be nearer than those of the smaller circles. Whilst the diagram above alluded to, answers well from its simplicity for the explanation of this pseudoscopic effect, it is not calculated to impress the peculiar nature of it upon the reader.

If the photographs of the stereograph of a real object are transposed, and the distances between the corresponding objects of the two pictures measured and compared, it will be found that the distance between the images of the same tree, for example, on the two pictures, will now be greater than that between the images of the same edge of a window before which it stands, instead of less, and when viewed by means of the stereoscope, as far as the two edges are concerned in assigning it a position, it should appear behind instead of in front of the window. Were there no other criteria of distance to influence the judgment in this case of a photographic landscape than that afforded simply by two eyes, this case would have no interest beyond that of the simple line diagrams of the frustum. But, as we have elsewhere explained, there is nothing in the nature of these diagrams to cause either of them alone to represent one frustum—that is, a concave or a convex—rather than another, but the play of the axes of the two edges upon them alone gives decided character to the resulting impression. The photographs of a real object, however, involve not only other monocular criteria of distance and form, but possess many of them in great perfection. The perspective, the relative sizes are accurately rendered; shading, etc., with less degree of perfection.

The struggle between the (so to speak) cumulative effect of these usual and monocular criteria of distance and the single binocular one of variation of the optic angle,—or movement of the optic axes,—placed at variance with natural effect by this arrangement of the pictures, is exceedingly interesting. As previously intimated, the binocular criterion is the most definite and absolute, yet, for a time, it will generally fail to assert itself. The face of an individual will refuse to become a hollow mask, as it should, or elevations to be converted into depressions, or trees in the foreground march back through the houses or rocks, and take their position in the rear, and be visible through the houses and rocks, imparting to them a peculiar unnatural transparency. The objects in the background scarcely succeed in

fighting their way to the front, in spite of the accurate perspective and the smallness of their relative sizes.

Any one in looking at such a picture at all closely, must feel a want of the usual satisfactoriness of stereoscopic views: he may even remark that the pictures do not unite well, and, in some cases, they may be regarded as too far apart, or the difficulty may be referred to defect of the particular instrument, until it has been tried with other stereographs. But sooner or later the play of the optic axes in passing from the points falsely represented to them as near to those with equal falsity represented as remote, overcomes all other influences upon the judgment, and the beholder yields to the deception; the objects appear turned inside out, the houses, rocks, etc., advance to the foreground and assume the unnatural transparency.

In experimenting in this way it will soon be noticed that some stereographs manifest this pseudoscopic effect much more readily and decidedly than others, that, indeed, some, especially of landscapes, do not manifest to the eye of a casual, unsuspecting and unpracticed observer any difference when mounted thus pseudoscopically. The effect may seem about as fine as when properly mounted. The reason for this is that in such pictures which generally have little foreground, and therefore few decided objects within the range of the play of the optic axes—the binocular criterion,—the geometrical perspective, relative size, and so forth, have a more decided influence upon the judgment, and overpower the, in this case, comparatively feeble binocular condition. In order to test this fact, the writer has frequently selected such views and transposed the pictures, and has found that the most practised observers with the stereoscope will frequently fail to detect the transposition. So views of long colonades, or of trees, which afford such decided geometrical perspective, will with difficulty be made to come into the new unnatural shape when the pictures are transposed.

These facts afford an additional argument for care in the selection of foreground for stereoscopic views, and explain the cause of the increased demand frequently for stereoscopic views inferior photographically and in general appearance, out of the stereoscope, to others by their side.

To such as will take the little trouble to acquire the power of uniting pictures by the second ocular method given,—by squinting to a point nearer than the stereograph,—a collection of stereographs will become a collection of pseudographs as well, without the necessity of

cutting and transposing them. The variety of effect as well as its singular character will well repay all the trouble. The effect in this case, as well as those in which the pictures are properly used, seems to be better, more exquisite, than when a stereoscope is employed, which to some extent magnifies them, destroys their miniature character, and reveals more clearly defects of paper, and so forth.

Villages with their rows of trees, cities with all their variety of composition, statuary, flowers, all present their own new and peculiar phases under this treatment, almost as surprising as the first encounter with stereoscopic effect upon the introduction of that instrument.

The writer during the past summer, at Watkin's Glen, N. Y., found several views that had been accidentally mounted pseudoscopically, which gave a most pleasing effect, though to persons unused to such views a most unintelligible one. Large logs in the foreground passed behind and became visible through the rocky ledges of the background, and so forth.

But stereographs do not alone allow us this pseudoscopic enjoyment. Views of real objects may be made to be taken on this false arrangement of details as to distances. Just as we see things naturally stereoscopically, because each eye receives its own proper view, so, by the aid of an instrument devised for the purpose, each eye may be made to receive the impression which belongs to the other, in looking at any object, and the object will in consequence appear pseudoscopic. Such an instrument, called a pseudoscope, will be described in connection with the stereoscope.

(To be continued.)

Immense Pumping Engine.—One of the most powerful pumping engines in the world has recently been completed in this city, designed for the Lehigh Zinc Company's Mines, at Friedensville, Pa. The engine has a pumping capacity of 15,000 gallons per minute, and may be run to 17,000 in case of emergency, raising water from a depth of 300 feet.

The steam will be supplied by 16 boilers, 50 feet long, 36 inches diam. and of $\frac{5}{16}$ inch iron.

Balanced valves, 20 inches in diam. and with $1\frac{3}{4}$ inch lift, admit steam to the cylinder, which is $110\frac{1}{4}$ inches diam. and 10 feet stroke. Cylinder weighs 30,398 lbs., and with heads, 81,736 lbs or 40 net tons.

The piston rod is of wrought-iron, 14 inches diam. and 22 feet long. Cross head weighs 15,740 lbs. and is attached to piston rod by a nut weighing 1,100 lbs. The total weight of the engine is 650 tons.

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EDITORIAL.

ITEMS AND NOVELTIES.

The Channel Ferry.—The scheme to establish a line of steamers, upon a grand scale, to convey passengers and freight across the channel between Dover and Calais, which was first proposed by Mr. John Fowler, about seven years ago, is again attracting serious public attention and awaking much discussion, *pro* and *con*, from the journals of the countries more directly interested.

The great advantages to be derived from some method of transit which shall meet the requirements of present commerce and insure increased facilities and comfort for passengers, has received practical recognition in the actions of the two governments concerned, both of which have passed bills favorable to the establishment of some superior practical plan of international communication.

We learn from a contemporary* that, at a recent meeting, held at Dover, to consider the plan above named, the representative of its projector made the following statements concerning it: First, that the engineers had determined to have no halfway measures, but to carry out a plan which would not require to be enlarged and altered,

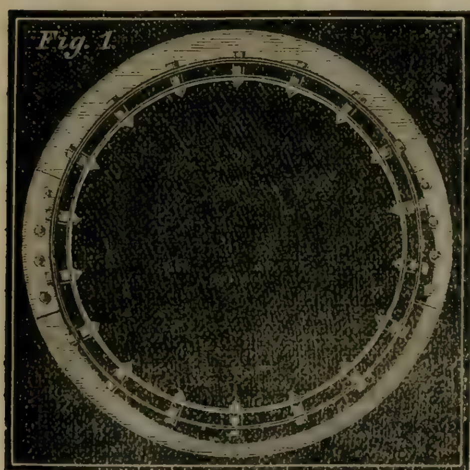
* Engineering, xiii, 43.

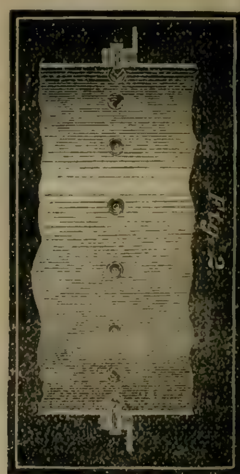
at loss of time, at additional expense, and at the cost of hampering and hindering the development of the great traffic anticipated; secondly, it was desirable, in their opinion, for the commercial success of the enterprise, that provision should be made for carrying the trains across the channel upon the steamers, so as to afford passengers an unbroken through train communication to Paris, and also that the same accommodation might be provided for goods.

Hooping Boiler Flues.—The recent report of the Engineer of the Manchester Steam Users' Association upon the application of encircling hoops to the furnace tubes and flues of boilers originally constructed without them, contains much information of a useful character. Want of space forbids the reproduction of more than a brief summary of this valuable document, to which, as well as to the pages of the leading English technical periodicals, we would refer those of our readers who desire to peruse the original.

"It is frequently found to be desirable to add encircling hoops to the furnace tubes of boilers already in use, either to admit of their working pressure being increased, or to render them safe at the one to which they may have been hitherto subjected." As these hoops, if not properly attached, give rise to serious trouble, the following report and illustrations were deemed serviceable:

"Fig. 1 gives a cross section of a furnace tube with encircling hoop, while fig. 2 gives a horizontal section, and fig. 3 an external plan view.

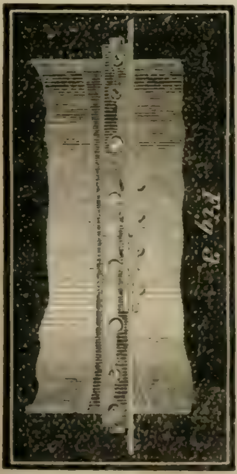


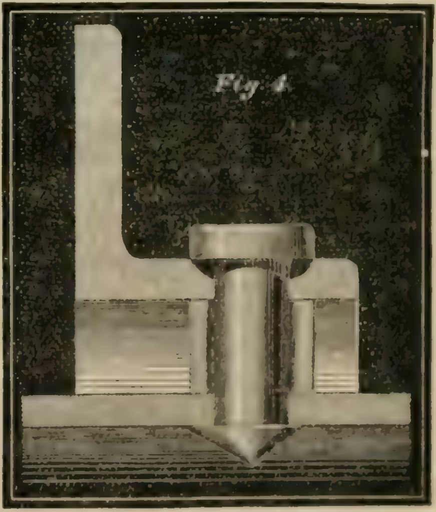


"The hoops should be of angle iron section, about 3 in. x $\frac{1}{2}$ in. They should be made in halves, so that they may be passed in at the manhole, and then riveted to the furnace or flue tubes in position, thus rendering it unnecessary to remove the tubes or to cut any opening in the boiler. The angle iron should not be brought into direct contact with the plates of the tubes, but a clear space of not less than an inch should be left between the two, the hoop for this purpose having a diameter some two inches larger than the furnace tube.

"The hoop should be secured to the furnace tube by rivets, spaced about six inches apart, blocking pieces through which the rivets should pass being inserted between the tube and angle iron, so as to give a solid abutment to the riveting, while the halves of the hoops should be connected together by butt strips riveted to their ends at the back. Sometimes these blocking pieces are made by cutting off a piece of bar iron, and punching a hole through it for the rivet. This plan is objectionable, as it forms too great a lump of metal around the rivet, and promotes the overheating of the plate. The blocking pieces should be made of a strip of iron not more than $\frac{3}{16}$ in. thick, bent round into a circular shape, the ends being welded together so as to form a short tube or ferrule."

A view of this mode of construction is given in fig. 4.





The object to be accomplished by the water space between the angle iron ring and the tube is to allow of perfect circulation of water be-

tween them, and thus to avoid the objection connected with the plan of attaching the rings directly upon the tube, in which the plate easily cracks at the rivet holes from the overheating of the tube.

"In fixing hoops in pairs, one hoop should be set a little out of line with the other, so that the flanges may not be in contact, or close enough to form a harbor for incrustation."

It is also "recommended that in every boiler of ordinary dimensions, one set of hoops should be applied to the tubes at about 5 feet from front end."

Shaw's Compound Propeller Pump.—In the illustrated description of this machine in our last issue, reference was made to the ingenious contrivance of a hydrostatic disc or water bearing, upon which is sustained the weight of gearing, shaft and water, and the downward reaction of the lifting power, thus effecting a great saving in power, and permitting of the economical use of pumps of great length. A good estimate of the amount of pressure exerted upon the bearing may be formed from the statement that a pump of this form, 20 inches in diameter and raising water to a height of 50 feet, with propeller blades and shaft weighing, say 1 ton, the total pressure to be sustained by the bearing is 4½ tons, or about 10,000 pounds, in which there is no estimate for the downward reaction of the surplus power needed to forcibly eject the elevated liquid. It is clear that with a bearing of ordinary construction the effect of this enormous pressure would be a great loss of power from friction, rendering pumps of considerable length altogether impracticable from an economical standpoint, even could materials be found of sufficient strength to resist so great a strain, combined with a velocity of 200 rotations per minute.

These serious objections the inventor has ingeniously met by the introduction of a water bearing, or device by which the shaft is lifted entirely from its rest by the pressure of a body of water which floats upon it, the entire pressure arising in any case from the causes above named.

This contrivance is shown, in external view and in proper position, at the end of shaft just beneath the pulley in fig. 1, and, in section, in fig. 2.

It consists of an outer stationary disk, supported from pillars resting on upper face of the pipe, and an inner movable disk, attached to, and rotating with the shaft. The hydrostatic pressure is applied by the force pump, indicated in fig. 1 by a pipe entering the lower face

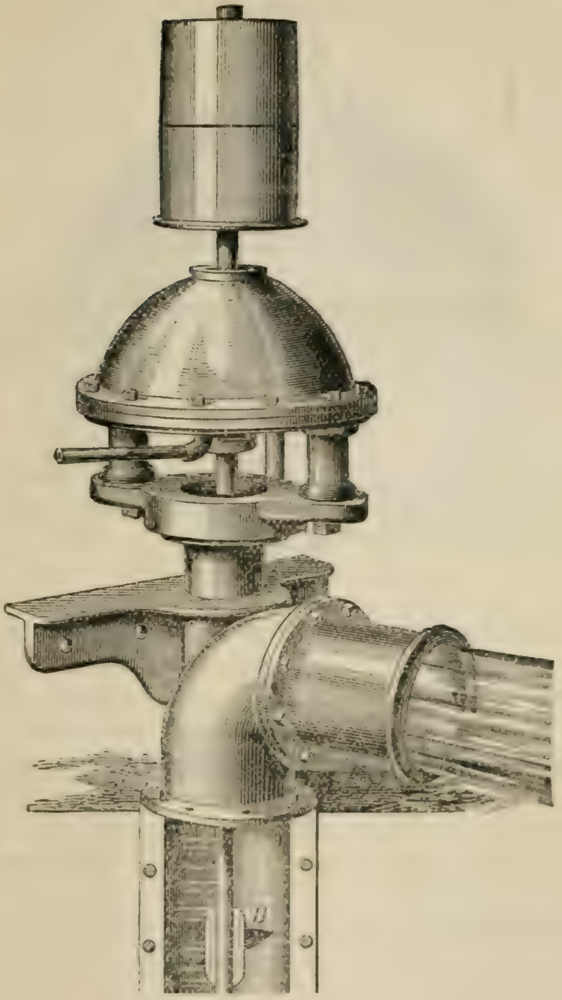


Fig. 1.

of outer disk; and, being operated by the engine driving the pump, forces a quantity of water between the faces of the disks. The result is the lifting of the inner disk (and with it the shaft) from contact with the outer one.

The water having performed its work is permitted to escape about the circumference of the disk, the escape being regulated by the device of an elevated edge in the outer, and a corresponding groove in the inner disk.

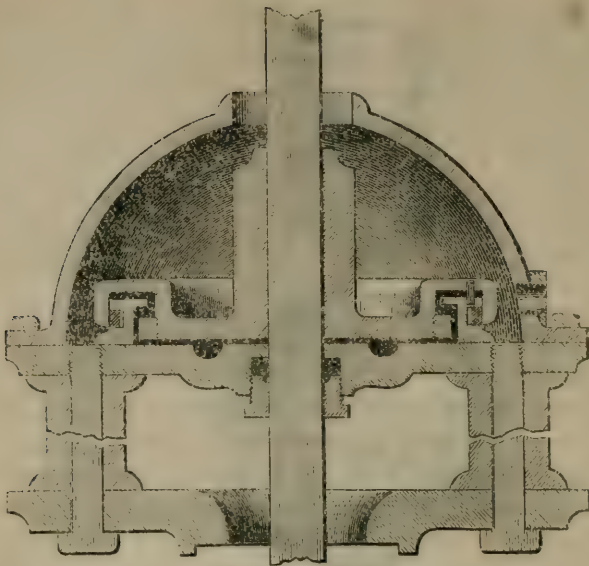


Fig. 2.

The problem of estimating the economy of the pump is rendered much easier by the water bearing; for seeing that, as much of the friction and pressure must be exercised upon the water, which would return it in the form of heat—the quantity of which stands in a well-known ratio to the amount of power consumed—it is only necessary to know the quantity of water escaping from the disk, and its increase in temperature, to be able to calculate the loss in transmitting the power directly to the shaft. The loss involved in friction of the elevated water column against sides of pipe is of course not here involved, but must be determined separately. From the former cause the loss has been estimated at only 5 per cent., a figure which bears testimony to the excellence of the invention.

Pressure in Steam Boilers.—The question as to whether the pressure in a steam boiler was equal or different at top and bottom, concerning which there seems to be some difference of opinion amongst engineers—though it is difficult, from the simplicity of the facts involved in considering the question, to see how a difference of opinion should exist—has nevertheless been experimentally determined by the Messrs. Hunter, at their establishment in this city. An elbow was attached to the end of the blow-off pipe which entered the mud-drum; into this a plug was screwed, and tapped to receive a half-inch pipe;

to this a steam gauge was attached and the cock opened. On comparing the indications of the gauges attached at top of boiler and to the top of drum, as above described, it was found that the pressure was greatest at the bottom, by a pound and a half, proving, as might readily have been predicted, that the pressure upon the bottom of a boiler is equal to the steam pressure indicated above, plus the weight of a water column equal in height to the difference in level between drum and surface of water in boiler, and in diameter to that acting on the gauge.

The Saint Gothard Tunnel.—Scarce has the world ceased its wonderment at some great scientific achievement, or engineering triumph over the obstacles of nature, when fresh schemes, still more gigantic, born of preceding successes, are projected.

The great advantage to be derived by France from the completion of the Mont Cenis tunnel, bringing the cities of that country in intimate communication with the nations of the East, has awakened anew a project to unite Switzerland and Germany by a similar tunnel through the Alps at the pass of St. Gothard. The plan is not altogether new, for ever since the former tunnel was perfected the Governments of Switzerland and Germany, influenced by the fear that a vast commerce would be built up and diverted into France by its successful completion, have appreciated the importance of opening a new commercial highway on their side of the Alps. National jealousies have doubtless served to prevent the plan here named from assuming a definite form; but now that these have been to a great extent removed by the events of the past year, we are informed* that the project has been revived, and that a contract for the construction of the tunnel has been definitely concluded between the Swiss government and a syndicate of the German bankers, backed by the support of the Imperial government of Germany.

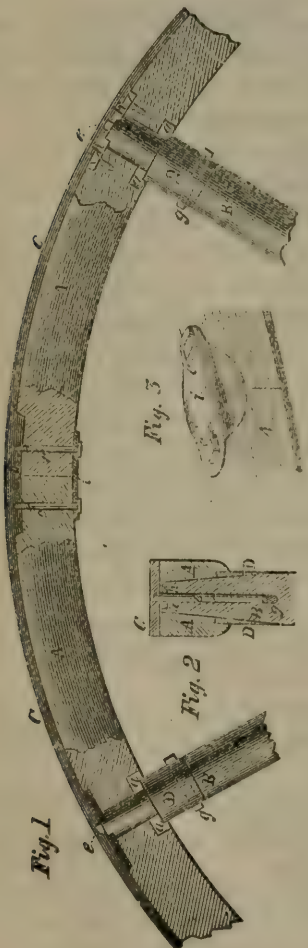
The importance of the projected tunnel in facilitating travel and influencing a vastly increased traffic between Asia and the north of Europe, cannot be overestimated, and the inauguration of the great enterprise will be looked for with interest by all.

The completion of the proposed tunnel will offer greater difficulties than that through Mont Cenis. It will be twice as long and through rocks more difficult to pierce. The estimated cost of the work is put at $37,000,000, and from the experience derived from Mont Cenis

* Iron World and Manufacturer.

and other similar works in various parts of the world, and the great improvements which have been made in tunnelling machinery, it is confidently anticipated that the enterprise will be brought to a successful termination in a proportionally much shorter time.

Improved Carriage Wheel.—The accompanying engravings illustrate an invention patented by J. T. Shelley, Esq., Pennsylvania, designed to secure the spokes more effectually in the fellies of wheels, and to attach the tire more securely to the wheel, at the same time preserving its strength.



By referring to the engraving, it will be observed that plates are welded upon the inner face of the tire, in such positions as to overlap the joints of the fellies. These plates, shown at *b*, are furnished with female screw threads to receive the ends of bolts, *c*, *c*, which firmly secure the fellies and tire at once, without requiring the drilling of the tire, and rendering it by so much the more durable. The spokes are attached to the wheel as follows. The ends of the spokes for fitting into the mortices of the fellies are tapered to admit of the attachment of an iron ferrule, *D*, which are made flush with the surface of spokes. There are wings, *a*, *a*, on either side of the ferrules to strengthen those portions of the spokes which enter the fellies.

A number of short grooves are made on the inner face of the tire, to correspond to the number of spokes, and each groove corresponds to a hole made in the axis of the spoke. Each of these passes down to a lateral oblong perforation in the ferrule *D*, and receives a pin, *e*, which, after having been properly wedged down, are firmly held by the key *g*, the ends of which are filed off even with the ferrule. To prevent lateral motion of tire or spoke, and the working loose of the pin, *e*, iron plates, *h*, are set into

the tire face of fellies across the ends of the spoke tenons secured by screws; which plates have perforations to correspond to the diameter of the bolts *e*.

Burnt Iron and Steel.—W. M. Williams has given the result of some inquiries into the causes of this phenomenon, to the Chemical Society of London. After some remarks upon the physical characteristics of the damaged materials, he asserts that he has found in all the samples of iron which he has subjected to examination, particles of black oxide more or less abundantly distributed throughout the mass. These are, however, absent in burnt steel. The method which he suggests of quickly deciding this question, is to take a small quantity of fresh borings or filings, and to cover them with some diluted nitric acid. As the iron dissolves, the free oxide separates and remains suspended in the liquid, rendering it dark in color. These particles shortly disappear, and are thus to be distinguished from separated carbon. No such discoloration takes place with good irons.

The cause of the burning of iron he explains as follows: As soon as the small quantity of carbon is removed from the heated mass by oxidation, this process extends to the iron itself—not only upon the surface, but into the interior. The higher the temperature, and the longer the exposure, the greater is the quantity of carbon necessary to protect the iron; and this, in the author's opinion, is the reason of the failure to produce merchantable iron by the Bessemer process. The high temperature and great exposure of the metal in the converter to the air, causes oxidation of the iron to take place even in the presence of considerable carbon. The best iron, therefore, should be that in which carbon is brought to the lowest possible proportion, without oxidation of the iron.

Burnt steel the author considers to be steel which has, by reheating, lost some of its carbon by oxidation, and by sudden solidification has had the resulting carbonic oxide imprisoned in the interior of its mass. The well known permeability of iron for certain gases renders such a process not difficult to understand.

The structure and properties of "burnt iron and steel," are therefore "caused by the presence of intermingled particles of combustion products breaking the continuity of the metal. The carbon is burnt in the case of the burnt steel, the iron itself in the burnt iron.

The Total Solar Eclipse in India.—M. Janssen writes to the perpetual Secretary of the Paris Academy from Sholoor-Neilgherry:

—"I have just a moment since observed the eclipse with an admirable sky, and now, while still feeling the emotions caused by the splendid phenomenon I have witnessed, I address these few lines, etc. . . . . The result of my observations at Sholoor indicates, without any doubt, the solar origin of the corona, and the existence of matter beyond the chromosphere."

To M. Faye, the President, he writes:—"I have observed the corona, which I was unable to do in 1868, when my whole attention was given to the prominences. Nothing could be more beautiful or more luminous, with configurations, which exclude all possibility of an atmospheric terrestrial origin. The spectrum contains a very remarkable green ray, already announced, which is not continuous as already stated, and I find indications of the dark lines of the solar spectrum; notably the well known double line of sodium, D."

All of the observing parties, except those at Melbourne, seem to have been successful. The observations of Professors Lockyer and Resphigi both confirm those of Janssen, concerning the solar origin of the corona. The former gentleman, in a letter to *Nature*, remarks: "The composition and structure of a part of the corona have been forever set at rest, while we have seventeen photographs taken by instruments of the same power and pattern, to compare with each other."

Boiler Explosions!—Under this title appears, in the "*American Railway Times*" of February 17th, an article the tenor of which is not only to show how utterly useless it is to seek for the causes of steam boiler explosions by experimenting under varied conditions with boilers which have actually seen service—as has lately been done in the tests made at Sandy Hook; or by experimenting with apparatus especially designed to reproduce every possible contingency which the perverse ingenuity of "practical" engineers can invent, as in the classical experiments made years ago, by a committee of the ablest men in the Franklin Institute; but to explain, in addition, just how boiler explosions really occur.

The off-hand way in which this author disposes of the Sandy Hook trials as those of "so called" but deceived experts, and the elevated stand-point from which he pronounces that "we are gravely told in some of our school-books on natural philosophy that experiments were made by a committee of the Franklin Institute," are calculated to excite an unusual degree of curiosity to hear an exposition of the author's own views upon a subject which he handles "as one having authority and not as the scribes." It will therefore not seem

surprising that upon reaching the announcement, "Let us now see what *does* cause explosions," we were scarcely prepared to meet with a rehash of the old gas theory, so effectually and repeatedly exploded, in one form or another, time and again, that it is really surprising it should possess vitality enough to make its appearance in a fresh garb, whenever from any cause public attention is directed to the subject of boiler explosions.

The author's case is simply this:—Should a surface of boiler or flue, from insufficiency of water, become overheated, say to red heat, the steam will necessarily come in contact with this red hot surface and be decomposed into its elements; the oxygen will be appropriated by the iron, the hydrogen will be liberated. If now, by any means, as the starting of the engine, the hydrogen collected in the upper part of the boiler should be brought into contact with the oxide of iron heated to the same temperature as will decompose steam, the iron will be reduced, the gases again combining with explosive violence.

It would hardly be worth while to enter into the discussion of this so-often-disposed-of subject, were it not for the fact that the author subscribes himself as professor of a university, and treats his subject from a chemical and not from a mechanical stand-point. A few brief comments will be found below:

1st. It is gravely to be doubted, whether steam in contact with glowing metal surfaces can be decomposed into its elements, so long as water is present with it. In a steam boiler, the mechanical suspension of more or less water in the steam we conceive to be unavoidable; but be that as it may, so long as we have nothing but bare assertions to oppose the results obtained by the Franklin Institute committee, we prefer to adhere to the latter.

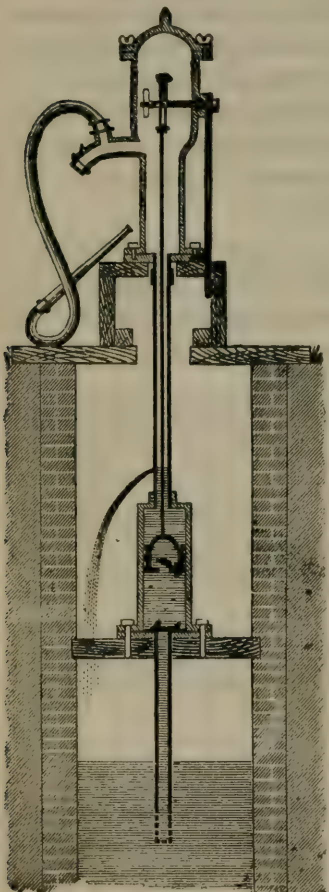
2d. Admitting that the steam is decomposed by the iron, that hydrogen is liberated and the oxygen bound up with the iron. the statement of the author that the contact between the oxide of iron and hydrogen, "*at the same temperature as will decompose steam*," will result in a reduction of the iron oxide, and a re union of the gases with explosive force, is palpably incorrect, since it is asserted that, under exactly the same conditions in which iron is strong enough to rob the hydrogen of its oxygen the hydrogen is strong enough to take possession of it again.

3d. Even admitting this chemical paradox, it is impossible that the hydrogen should reduce the oxide of iron with explosive violence.

The assertion will be opposed by the repeated experience of every practical chemist.

The employment of hydrogen as a reducing agent for numerous metallic oxides is a matter constantly recurring in the laboratory, and this process, so far from taking place with explosive violence, on the contrary is often a tediously gradual one. The assertion, therefore, that hydrogen will produce so violent an action with iron oxide is unsupported by any fact known to the chemist, but is contrary to his almost every day experience.

While agreeing with the author that "the best judge of any science or art is a person who has made science or art his particular study," inquiring minds will be disposed to call for something more than mere statements to support even a theory as fascinating as his appears to be.



A Force and Lift Pump.—The accompanying figure represents a pump, manufactured by the American Pump Company, Philada., and exhibited at a late meeting of the Franklin Institute.

The pump for out-door work here represented, is secured to a plank or timber, and is connected by a pipe to the water to be lifted. The plunger rod is worked by a rocking shaft running through the side, instead of working, as ordinarily, through the top. The handle is attached to the outer end of shaft, thus permitting the top to be closed by a hinged lid, secured by thumb screws, and forming an air chamber. When this is off, the machine is a simple lift pump; when on, it is converted into a force pump, throwing a continuous stream with considerable force.

Problem of the Rafters.—Since the article on page 100 of the present volume of the *Journal* was published, I have found that Prof. Rankine, in his Civil Engineering article 179, page 292, has given the

correct formulas for this case. My formulas agree with his when the *notation* is so changed as to agree with each other. DE V. W.

Errata.—Page 104, second line from the bottom, for wxAB read wAB.

Page 106, second line from the bottom, the line bf referred to is not shown in Fig. 6.

Page 107, near the middle of the page in equation for compression, for Cos^2 read $Cos^2\theta$.

The Cost of Tunnelling.—The *London Times*, in a recent article, gives a tabulated statement of a number of the more important tunnelling enterprises, from which we learn that the cost per linear yard of the works below named were as given:

Mont Cenis, $975; the Kilsby, the Saltwood and the Bletchingley, the costliest of the English tunnels, cost $725, $590 and $360 respectively. That of Terre Noire (France) cost $475, and the Hoosac, in Massachusetts, has thus far averaged $940.

Adulteration of Aniline Colors.—The intense tinctorial power of the aniline dyes seems to offer irresistible temptation to dishonest dealers to imitate or adulterate them with worthless ingredients. A sample of fuchsine (an aniline red) lately placed in our hands by Dr. Genth was composed entirely of sugar crystals saturated with the coloring matter. To any one familiar with the peculiar arborescent appearance of the pure fuchsine particles, the sugar crystals, with their rhombic prisms, would betray the imposition at a glance; but without this knowledge the detection would be attended with some difficulty, since the color of both genuine and counterfeit samples is equally intense. One of the simplest methods to detect this and similar impositions is simply to digest a sample of the suspected substance in ether or absolute alcohol, when the coloring matter will be dissolved with ease, and the sugar, crystals, or wood fibre (which is also used for dishonest purposes) will remain undissolved.

Arsenic in Colored Carpetings.—Hallwachs* has found that not only green but also the red colored carpetings frequently contain arsenic. He particularly asserts that the brilliant dark red colors, now so greatly in demand, contain enormous quantities of this poisonous substance. The goods burned with the blue flame of arsenic, and gave its characteristic garlic odor. Enough of the color could be

* Gewerb. f. d. Grossh. Hessen., 169.

rubbed off with the finger to give a distinct precipitate of arsenic with the usual reagent, and in solution in hydrochloric acid covered some copper pieces with the greyish coating characteristic of the substance.

A Lecture Experiment.—V. Wartha describes a neat method of illustrating the presence of sulphur in illuminating gas. He places, on a platinum wire, a bead of carbonate of soda on the edge of the flame of a Bunsen burner for a minute, and obtains then, by partially cutting off the air supply, a small cone of light in the flame. Into this the bead is placed, and the sulphate and sulphite of soda previously formed is brought to the condition of sulphide of sodium by the reducing action of the glowing carbon particles. The bead is then crushed in a porcelain dish, and a solution of the nitro-prusside of sodium added, when the characteristic reaction of sulphur is readily obtained. The reaction is said to be more than fifty times as sensitive as that with silver, which is ordinarily used. A minute suffices to obtain it.

Litmus Paper as a Reagent.—A paper upon the sensitiveness of litmus paper in indicating the presence of alkalies or acids, has recently been published* by Mr. Chas. Bullock, from which it appears that a reaction may be obtained with one drop of 30 per ct. acetic acid in the following quantities of water: In 4 oz. it turns red immediately; in 6 oz., in half a minute; in 10 oz., turns red on edges in one-fourth minute, completely in one minute; in 13 oz., completely red in one and one-half minute; in 16 oz. the limit of distinct reaction is reached. With an alkali the following results were obtained: With one grain of andhyd. carb. soda in 32 oz. of water the bluing occurred in one minute; in 56 oz., in three minutes; in 64 oz., in four minutes; in 80 oz., in seven minutes; in 160 oz. of water the limit of distinct reaction is reached.

The Argentotype.—A photographic process called by its inventor, Mr. F. A. Wenderoth, of this city, by the above name, is in operation, and from the great beauty of the results promises to become largely introduced. The general outline of the process will be understood from the following description:

A carbon print is made in the ordinary way, by exposing a bichromated gelatin film beneath a negative. A silvered metallic plate is

* Am. Jour. of Pharmacy, Jan., 1872.

next taken, and rubbed with a sanded brush, to depolish the surface and heighten the effect of the picture. The plate, after cleansing, is laid on a sheet of paper, on a table containing diluted alcohol. The carbon point is now brought face down in contact with the plate, a paper sheet is laid upon it, and by a simple roller, the alcohols and air bubbles are forced from between plate and print, and the two made to adhere firmly. The plate with film is now immersed in water of about 100° F. and developed, leaving a film of varying thickness on the plate through which the lights are in the thin parts, and the shades in the thick insoluble parts. The character of the metallic surface gives a peculiar tone to the picture, and the shades may be varied by using colored gelatin.

To render his pictures more durable, Mr. Wenderoth attaches them by a simple method hermetically to glass plates. The same artist is operating a photo-zincographic process, which is new in some respects, an illustration of which we will shortly be able to give.

Formation of Ozone.—Dr. Pincus states that ozone is formed during the burning of hydrogen; and that if a flame of this gas is allowed to burn from a fine point, the smell of ozone can be distinctly recognized. This statement recalls to mind the announcement made some time since by Loew, of New York, that ozone might be obtained in sufficient quantity for purposes of lecture demonstration, by simply blowing the heated air on the edge of an ordinary Bunsen flame, with the aid of a glass tube, into a glass receiver, containing the ordinary reagent for testing an oxidizing agent—iodide of potassium, acetic acid and starch—when the blue coloration of the iodide of starch almost instantly makes its appearance. At the time, Loew's announcement met with some objectors, who sought to explain the phenomenon by assuming that the oxidizing process originated with certain oxidized nitrogen compounds formed by the heat of the flame. From the fact, however, which is well-known to chemists, that it is impossible to unite nitrogen and oxygen directly, by any means short of the electrical spark, the explanation of Loew would seem to be the correct one.

To Determine the Value of Aniline Colors.—Armand Müller suggests the use of collodionized glass plates upon which an alcoholic solution containing a known percentage of the color to be estimated is fixed, and compared with similar films containing certain known quantities of a normal color. By this process he declares it possible to determine the value of different colors with great nicety.

Utilization of Slag.—A method of utilizing slag, in use at the blast furnaces at Osnabrück, in Hanover, is to allow it to fall in a stream from a height of about eight feet into water. It is thus granulated into particles of the size of a bean. From the water tank it is lifted by an elevator into cars and conveyed away, to be used in ballasting the roads and railways. We have the authority of Mr. Brockbank for the assertion that the Bessemer slags of the hæmatite furnaces make an excellent concrete from the large per centage of lime contained therein.

Editorial Correspondence.

The item on page 75 of the present volume has elicited the following communication, which, of course, necessitates the omission of the term novel there applied to it.—Ed.

PHILADELPHIA, Jan. 27th, 1872.

W. H. WAHL, ESQ., *Secretary Franklin Institute, Philada.*

DEAR SIR,—The signal to warn train men standing on the tops of cars, on their approach to an overhead bridge, to which you alluded at the last meeting of the Institute as a novelty, was introduced upon the Pennsylvania Railroad in April, 1867, and is now in general use upon that road.

I am informed by Mr. T. J. Heizmann, engineer, who first introduced it, that about that time he saw a newspaper paragraph speaking of its use on a railroad in Connecticnt, and its adoption on the Pennsylvania Railroad was suggested thereby. Yours, truly,

ENOCH LEWIS.

Civil and Mechanical Engineering.

THE LOCOMOTIVE ENGINE, AND PHILADELPHIA'S SHARE IN ITS EARLY IMPROVEMENTS.

By Joseph Harrison, Jr., M. E.*

Some persons care little or nothing for the past. Musty records and old things have no charm for them, and their lives seem centred in the one word, "Now." Perhaps they may be right in their abstract way of viewing the question, and they might well be pardoned for saying *cui bono.*

Others, again, omit nothing in their efforts to explore all that can possibly be reached of record or memorial, telling of the earlier days of the world on which we live, and of the doings of the inhabitants thereof. They never weary in lavishing time, trouble and expense, in following their favorite pursuit, and often are fully repaid, after long and laborious research, in the mere bringing to light of some trifling relic of may-be doubtful value, or some record not worth, perhaps, the time it has taken to secure it.

In the researches of the antiquary how little, however, is brought out of the inner workings of the individual minds which have evolved the beautiful and the practical in Art, in Science, and in Mechanism, even in comparatively recent days. It is the detail of their work that those interested in the subject so much desire, and do not find. They would know the ways and the means, and the chain of reasoning or experiment, whereby these early workers produced the results that are left to us. And how interesting is the little that has come down to our time.

The engineer, noting the curious things in bronze and in copper, exhumed at Pompeii, and gathered together in the Museo Borbonico at Naples, will linger near a small vessel for heating water, little more than a foot high, in which are combined nearly all the principles involved in the modern vertical steam boiler—fire-box, smoke-flue through the top, and fire-door at the side, all complete ;—and strange to say, this little thing has a *water-grate*, made of small tubes crossing the fire-box at the bottom, an idea that has been patented twenty times over, in one shape or another, within the period of the history of the steam engine.

*This paper was written before the publication of a recent work on the early history of the Locomotive in the United States, by ——— Brown, and all that is stated herein, after Oliver Evans' time, is from personal observation. The author has not seen the work alluded to in this note. J. H.

The architect, looking at the faded drawings made many centuries ago, and still serving as a guide in the completion of that epic in stone, the wonderful Cathedral on the banks of the Rhine, at Cologne, is interested not only in the beautiful forms and proportions portrayed in these now dim lines, made by the architect whose name is still preserved to us, but in noting the changes and alterations that mark their gradual approach towards perfection, showing plainly that revision and variation from the original design, was as necessary then as now, if perfection was to be achieved. These are even still extant in record if not in drawings; examples of Roman architecture indicating the same slow approach towards a more perfect ending, in the erection of the monuments that now excite our wonder, built to adorn the Capitol of the world more than two thousand years ago.

Knowing what we know, and seeing what we see of improvement and advancement in mechanical and engineering science and art all around us, how interesting it is to look at the first condensing steam-engine made by James Watt, and the little locomotive "Rocket," of George and Robert Stephenson, both so carefully preserved in the South Kensington Museum in London.

The history of a most remarkable machine, now so necessary in our daily wants, had its real commencement but forty years ago, and yet much that is exceedingly interesting in the detail of its early introduction and improvement is unknown to this generation, and before many years all those who labored at its beginning, and who only can tell the story of its early progress towards its present perfection from their personal knowledge, will have passed away.

To prevent this loss in part, an effort will be made in the following pages, without going too much into technical detail, to bring together some facts in connection with the early and very important work of Philadelphia Mechanics and Engineers in the origination and in the development of the improvements in the LOCOMOTIVE ENGINE.

In the opening part of an article printed in a supplement to the Encyclopædia Brittanica, 1824, may be found the following: "RAIL-WAYS.—A species of road or carriage way, in which the track of the carriage wheels being laid with bars or rails of wood, stone or metal, the carriage is more easily drawn over this smooth surface than over an ordinary road." And further, in the same article, after alluding to the early history of rail-ways in Great Britain, and touching on the chief lines then in use, the article continues: "From these accounts of the chief rail-ways in England and Wales, it will appear that this

species of inland carriage is principally applicable where trade is considerable, and the length of the conveyance short, and is chiefly useful in transporting the mineral products of the kingdom from the mines to the nearest land or water communication, whether sea, river or canal. Attempts have been made to bring it into more general use, but without success, and it is only in particular circumstances that navigation, with the aid of locks or inclined planes to surmount the elevations, will not present a more convenient medium for an extended trade.

"South Wales, however, presents an example where the trade being great, and also chiefly descending, the country rugged, and the supply of water scant, rail-ways have been adopted with complete success, and have been found, in some cases at least, equal to canals in point of economy and dispatch." After further discussing the topic, the conclusion of the article is as follows: "On some of the railways near Newcastle the wagons are drawn by a steam-engine placed on a wagon by itself, the wheels of which are driven by the engine, and, acting on a rack laid along the rail-way, impel forward the engine and the attached wagons. In some cases, the wheels of the wagon operate without rack-work, by the mere friction between them and the rail. The steam-engines employed for this purpose are of the high pressure kind, these requiring no condensing apparatus."

"But this application of steam has not yet arrived at such perfection as to have brought it into general use."

When it is considered that but a generation and a half has passed since its publication, the above reads strangely in the light of our present knowledge and experience. It is noteworthy, too, that in the article from which the above extracts have been taken, there is not one word in relation to the transportation of passengers by railroad, nor is the name of "LOCOMOTIVE," since become so distinguished, once used.

During the five years following the publication of the above, little was done towards the improvement of the motive power for working the railroads of Great Britain, the only country in which they were used. In 1829, when the Liverpool and Manchester Railroad (the pioneer of a new system which has since attained such tremendous proportions) was well advanced towards completion, the locomotive was so unimportant an agent, that it was even then not easy to decide the question of motive power for working that important line. The locomotive had its friends in the Stephensons, father and son,

—in Hackworth, Braithwaite and Erickson, Trevethick and others. A plan for placing fixed steam engines at intervals along the line to draw the trains by endless ropes running over pulleys, had its supporters. Horses were looked to as a safe means to fall back upon when all else should fail. A machine to use horse power was even thought of, and was afterwards built, in which the propelling horses were carried on the carriage that was to be used for drawing the train.

During the year 1828 it became imperative, on the part of the Directors of the Liverpool and Manchester Railway, to decide in some way the question of motive power, and in that year a deputation of this body "was appointed to visit the railways of Northumberland and Durham, where the different varieties of motive power were most extensively practised." This deputation returned from this mission without coming to any conclusion as to which class of motive power would most conduce to their interests. They *did*, however, decide "that horse-power would be inapplicable for the great traffic that was anticipated upon the new line."

By this decision the question was narrowed down to the locomotive engine (then gradually becoming the favorite) and the fixed engine. This latter device was known to be clumsy in its management, and difficult to manage where a large traffic was to be carried on, or where it was of primary importance that a greatly increased speed must be aimed at. Little scope, therefore, was left in the fixed engine system for improvement tending to meet these essentials, and little could be expected. At this point in this most important controversy, it was suggested that the surest way to bring out the merits of the locomotive system, was to excite competition on the part of its advocates by the offer of a premium or reward for the best locomotive engine. In the spring of 1829, and in accordance with this idea, first enunciated by Mr. Harrison, a member of the Board, it was decided by the Directors of the Liverpool and Manchester Railway, to make this premium £500, to be contended for under conditions to be fixed by the Company.

The very important conclusions which soon resulted from the competition induced by the above offer, in the rapid improvement of the locomotive engine, formed a new era, not only in *their* history, but in the importance of railways generally. The conditions upon which the premium was offered was in part as follows:

"RAILWAY OFFICE, LIVERPOOL,
25th of April, 1829.

"STIPULATIONS AND CONDITIONS

On which the Directors of the Liverpool and Manchester Railway offer a premium of £500, for the most improved locomotive engine.

"1st. The said engine must 'effectually consume its own smoke,' according to Railway Act. 7th Geo. IV.

"2nd. The engine, if it weighs six tons, must be capable of drawing after it, day by day, on a well constructed railway, on a level plane, a train of carriages of a gross weight of *twenty tons*, including the tender and water tank, at the rate of *ten miles* per hour, with a pressure of steam on the boiler of *fifty pounds* to the square inch.

"8th. The price of the engine that may be accepted is not to exceed £550, delivered on the railway; and any engine not approved is to be taken back by the owner."

The following engines were entered for the prize:

The "Novelty," by Braithwaite and Erickson.
" "Rocket," by Robert Stephenson.
" "Sans Pareil," by Timothy Hackworth.
" "Perseverance," by Mr. Burstall.

All these engines had distinct principles in their construction, the most important of which being in the plan, and in the steam generating properties of the boilers.

After a fair test of all the locomotives competing in accordance with the regulations fixed, the prize was easily won by the "Rocket," built by George and Robert Stephenson; this engine having fulfilled, in some respects, more than all the requirements of the trial.

It is remarkable that the "Rocket," in all or nearly all of the essentials that go toward making the locomotive what it is, was as complete as the engine of our day. Its weight was but 3 tons, 1 cwt. From the success achieved by the "Rocket" at Liverpool, the locomotive engine took the place it now fills so perfectly, as the great motor for land transportation. All other devices were at once abandoned.

The type of locomotive established by the success of the "Rocket" became the then standard in England, and the Directors of the Liverpool and Manchester Railway lost no time in stocking their railway with engines, mainly after this model.

With this preliminary, it is now the purpose of this article to tell the early story of the locomotive in Philadelphia, and an effort will be made to show how great a share the minds and hands of our engineers and

mechanics have had in the improvement and development of (without doubt) the most important agent of this or any other age. In telling this story completely, it will be necessary to take a retrospect and go back to the year 1786.

In that year, Oliver Evans, a man who deserves at this day all honor at our hands as one of Philadelphia's noblest sons, "petitioned the Legislature of Pennsylvania for the exclusive right to use his improvements in flouring mills and steam carriages in his native State. In the year following he presented the same petition to the Legislature of Maryland. In the former case he was only successful so far as to obtain the privilege for the mill improvements, his representations respecting steam carriages savoring too much of insanity to deserve notice."

"He was more fortunate in Maryland, for although the steam project was laughed at, yet one of his friends, a member, very judiciously observed that the grant could injure no one, for he did not think that any man in the world had ever thought of such a thing before. He therefore wished the encouragemeut might be afforded, as there was a prospect of its producing something useful." The exclusive privilege was granted, and after this Mr. Evans considered himself bound in honor to the State of Maryland to produce a steam carriage as soon as his means would permit him.

To Oliver Evans must be awarded the credit of having built and put in operation the first practically useful high-pressure steam engine, using steam at 100 pounds pressure to the square inch, or more, and dispensing with the complicated condensing apparatus of Watt. The high-pressure engine of Evans had advantages for us in its greater simplicity and cheapness, and ever since his day it has continued the standard steam engine for land purposes in this country.

English writers have tried to detract from the fame of Oliver Evans, but it is well known that early in his engineering life he sent drawings and specifications of his engines, &c., to England by the hands of Mr. Joseph Stacy Sampson, of Boston. It is well known also that these drawings, &c., were shown to and copied by engineers in England, and from this period dates the introduction into Europe of the first really useful high-pressure steam engine, now so generally applied to locomotive and other purposes.

Basing his hopes of success on the use of the high-pressure engine in his steam-carriage, Oliver Evans, notwithstanding the opposition and even the derision of his best friends, and of almost every one,

made earnest efforts in the beginning of this century to carry out his design for building his favorite machine, but without success. He had a good friend in Mr. Robert Patterson, then Professor of Mathematics in the University of Pennsylvania, who recommended the plan as highly worthy of notice, and who wished to see it tried. Evans' plans were shown to Mr. B. H. Latrobe, a scientific gentleman of great eminence in his day, who publicly pronounced them chimerical, and who attempted to demonstrate their absurdity in his report to the American Philosophical Society on "*Steam Engines*," in which he also undertook to show the impossibility of making steamboats useful.

In Mr. Latrobe's report, Mr. Evans was said to be seized with the "*steam mania*," which was no doubt most true. To the credit of our then and now most learned Society, the portion of Mr. Latrobe's report which reflected so harshly upon Mr. Evans was rejected, the members conceiving that they had no right to set up their opinions as an obstacle in the way of an effort towards improvements that might prove valuable for transport on land. The Society did, however, admit in the report the strictures on steamboats.

Oliver Evans never succeeded in constructing a steam-carriage such as he had contemplated. It was commenced, and unaided he spent much time and money in fruitless efforts to complete it. Finding himself likely to be impoverished if he persisted in the scheme, he finally abandoned it, and devoted his time thereafter to the manufacture of his high-pressure steam engine and his improved milling machinery. Previous, however, to the final abandonment of his favorite project, Oliver Evans, on the 25th of September, 1804, submitted to the Lancaster Turnpike Company a statement of the cost of and probable profits of a steam-carriage to carry *one hundred* barrels of flour *fifty* miles in twenty-four hours, tending to show also that one such carriage would make more nett profit on a good turnpike road than ten wagons drawn by five horses each. He offered to build a steam-carriage at a very low price. Evans' statement to the Turnpike Company closed as follows: "It is too much for an individual to put in operation every improvement which he may invent. I have no doubt but that my engines will propel boats against the currents of the Mississippi, and wagons on turnpike roads. with great profit. I now call upon those whose interest it is to carry this invention into effect." Oliver Evans, in the early part of 1804, came nearest to realizing his favorite idea, in obtaining an order from the Board of Health of Philadelphia to construct at his foundry (a mile and a half from the

water) a dredging machine for cleaning docks, the first one ever contrived for dredging by steam, now so common.

To this machine Evans gave the name of "Oructor Amphibolis," or Amphibious Digger, and he determined, when it was completed, to propel it from his workshop to the Schuylkill River, which was successfully done, to the astonishment of a crowd of people gathered together to see it fail. When launched, a paddle-wheel, previously arranged, was applied to the stern, and again it was propelled by steam to the Delaware, leaving all vessels half way behind in the trip, the wind being ahead. This result Evans hoped would have settled the minds of doubters as to the value of steam as a *motor* on land and water. But his attempt at moving so great a weight on land was ridiculed, no allowance being made by the *hinderers* of that day for the disproportion of power to load,—rudeness in applying the force of steam for its propulsion, or for the ill form of the boat. A rude cut of the "Oructor Amphibolis" is still extant, which shows a common scow, mounted on four wooden wheels, with power applied to the whole number of the wheels by the use of leathern belts. Evans, after this experiment, willing to meet the question in any way, silenced the *carpers* around him by offering a wager, that for $3000 he would make a steam-carriage that would run on a level road as swift as the fastest horse they could produce. His bet met with no takers. This movement by steam power of Oliver Evans' dredging machine on land was, without any doubt, the first application of steam to a carriage in America, and in fact the first locomotive engine. It was a more important experiment than any that had preceded it, anywhere, in the same direction.

Oliver Evans' conceptions respecting the power of steam, many of them practically exemplified by him, reflects great credit on his sagacity as an engineer, and many of his predictions in regard to its great value, particularly for land transport, may well be termed prophetic.

In the early part of this century he publicly stated that "The time will come when people will travel in stages moved by steam engines, from city to city, almost as fast as birds fly,—fifteen or twenty miles an hour. Passing through the air with such velocity, changing the scene in such rapid succession, will be the most exhilarating exercise." "*A steam carriage will set out from Washington in the morning,—the passengers will breakfast in Baltimore,—dine in Philadelphia, and sup in New York the same day.*" "To accomplish this, two sets of railways will be required, laid so nearly level as not to deviate more

than two degrees from a horizontal line,—made of wood or iron, or smooth paths of broken stone or gravel, with a rail to guide the carriages, so that they may pass each other in different directions, and travel by night as well as day." Much stress is laid upon these early efforts of Oliver Evans towards the introduction of steam for land and water transportation, and much space has been given here to set them forth. With no light to guide him (for it is fair to suppose that he knew nothing of the little that had been done up to his day in Europe), how his trumpet-tones ring out in the words above quoted, compared with the "uncertain sound" made by the English engineers in 1829. *They*, with a quarter of a century or more of later experience, during which period much had been done to improve and develope the locomotive engine, hesitated and doubted in their course. *He*, with no misgivings as to the result, and with no dimmed vision, saw with prophetic eyes all that we now see. To *him* the future picture, in all its grandeur and importance, glowed in broad sunlight. In the history of these efforts of Oliver Evans it is noteworthy, and most creditable to our sister State of Maryland, that that Commonwealth extended to him the first public encouragement in his steam-carriage project. Again our enterprising neighbor was first in the field since become so important, for we find that in March, 1827, the State of Maryland chartered the first railway company in America, and in 1828 her citizens commenced the construction of the Baltimore and Ohio Railway, aiming to cross the Alleghenies; certainly the greatest railway scheme that had been thought of up to that date, and now, in its completed state, a triumph of railway engineering. To this first effort to make a great railway in the United States, and its influence upon the history of the locomotive in Philadelphia, reference will be made hereafter.

Oliver Evans died in 1819 and his plans for a steam carriage died with him, and although he produced nothing practically useful in the great idea of his life, he has left behind him an enduring monument in his grain and flour machinery.

[NOTE. The improvements of Oliver Evans in grinding flour, as described in his "Young Millwrights Guide," (a standard authority at this day on the subject of milling), changed the whole system of handling grain and its products. The principles and, in many respects, the arrangements in detail of the great grain elevators used so extensively at the present day, came originally from the teeming brain of Evans. In the first edition of the Young Millwrights Guide,

published eighty years ago, an engraving may be seen of an elevator unloading a vessel at the river side, and conveying the grain to an upper granary on the wharf, just as it is done to-day. It is painful to read Evans' own story of his struggles against the prejudiced and doubting men of his time in his efforts to introduce his improved milling machinery. Those who were ultimately most benefited by his inventions were his most persistent opponents. But he triumphed at last in this, although failing to get his steam carriage into use.]

The materials for the history of the next attempt at making a steam carriage in Philadelphia, eight or nine years after the death of Oliver Evans, are not very full. At this period a steam carriage to run on a common road was projected by some parties in our city whose names cannot now be easily reached. This steam carriage was built at the small engineering establishment of Nicholas and James Johnson, then doing business in Penn street, in the old district of Kensington, just above Cohocsink Creek.

An eye witness of its construction, and who saw it running under steam on several of its trials, describes it as an oddly arranged and rudely constructed machine. It is believed to have had but a single cylinder, set horizontally, with connecting-rod attachment to a single crank at the middle of the driving axle. Its two driving wheels were made of wood, the same as an ordinary road wagon, and were of large diameter, certainly not less than eight feet. It had two smaller wheels in front, arranged in the usual manner of an ordinary road wagon, for guiding the movement of the machine. It had an upright boiler hung on behind, shaped like a huge bottle, the smoke-pipe coming out through the centre at top, formed the neck of the bottle. On its trials, made on the unpaved streets of the neighborhood in which it was built, this steam carriage showed an evident lack of boiler as well as cylinder power. It would, however, run continuously for some time and surmount considerable elevations in the roads. Its safety valve was held down by a weight and lever, and it was somewhat amusing to see the puff, puff, puff, of the safety valve as the machine jolted over the rough street. This was before the days of spring balances for holding down the safety valves of locomotives. This engine was sometimes a little unmanageable in the steering apparatus, and on one of its trials, in coming over the High bridge and turning up Brown street, its course could not be changed quick enough, and before it could be stopped it had mounted the curbstone, smashing the awning-posts, making a demonstration against the

bulk window of a house at the south west corner of Brown and Oak streets.

After this mishap it was not seen on the streets again, nor is it known what ultimately became of it. This last effort may be classed, in some respects no doubt, with what Oliver Evans promised in his mind to carry out, and it is very evident that up to its time no great amount of knowledge or of practical or theoretical skill had been brought to bear upon the construction of locomotives in Philadelphia. No books were as yet published in America describing the locomotive, or telling what had been done in land transport by steam in Europe. The trials on the Liverpool and Manchester railway in 1829 had not been made, and a better result could have hardly been expected than this recorded above.

With the wonderful success of the "Rocket" in October, 1829, the attention of our engineers and capitalists was strongly turned towards this new revelation in land transport, that had so suddenly flashed upon the world. It was a matter of the greatest importance to us, with our rich lands everywhere teeming with produce, the producers meanwhile crying aloud for better means to get their harvests to market, and for getting our people, too, more speedily from point to point, that we should know more of this new thing, and if it fulfilled its promise, to get the advantage of it as soon as possible. It did not take long to come to a decision that railways *must* be built, and that speedily. It has been seen that Maryland took the lead, and had her great road well under way before others States looked the question fairly in the face. South Carolina followed the lead of Maryland, and granted a charter at an early period to the South Carolina Railway, intending to cross the whole breadth of the State, and ultimately aiming to reach the far west. Signs of railway movement were seen in Pennsylvania, Delaware and New Jersey, and in New York and New England. The Columbia railroad (a State work) was projected in Pennsylvania at this time, and the Philadelphia, Germantown and Norristown Railroad was begun in Philadelphia. New Jersey had chartered and commenced her road from Camden to Amboy, and little Delaware, ahead of all the States north and east of her, had two miles of the New Castle and Frenchtown Railroad ready for use on the 4th of July, 1831. The South Carolina Railroad was amongst the first to encourage the manufacture of American locomotives, and Mr. Horatio Allen, a gentleman honored still as a good citizen and as one of the first engineers in the country, designed and had built, in 1830 and '31, at the West Point foundry, in New York, the two first locomotives, it is be-

lieved that were ever ordered and made in the United States for regular railroad traffic.

The engines did good service on the South Carolina Railroad, and it is curious to note that Mr. Allen's locomotive embodied in this construction every valuable point of the "Fairlie" engine, now making so much noise in England. These points being the use of a vibrating truck at both ends with cylinders thereon, fire-box in the middle between two cylinders, with flues from fire-box to each end of the boiler, double smoke-box and double chimney, with fire-door at the side of fire-box, flexible steam and exhaust pipe, &c.

[NOTE. The first locomotive ever run on a railroad in America was undoubtedly the "Lion," one of two engines built at Stourbridge, in England, under the direction of Mr. Horatio Allen, and imported into this country in the autumn of 1829, for the Delaware and Hudson Railroad in the State of New York. Mr. Allen, in describing its first movement, says that he was the only person upon the engine at the time, and he (living still) made the first trip by steam on an American railroad. The "Lion" built before the "Rocket," had vertical cylinders, arranged somewhat after the manner of the old style of Killingworth engine, with four driving wheels all connected. The boiler of this engine approached somewhat to the locomotive boiler of the present day, in having a fire-box with five flues leading to the smoke-box, this latter feature being, in fact, the first step towards the present multi-tubular boiler.]

The Directors of the Baltimore and Ohio Railroad in January, 1831, by advice of Mr. Jonathan Knight, of Pennsylvania, still taking the lead in the railroad movement, and with the desire to encourage American skill, adopted the same plan that had been so successfully carried out at Liverpool in 1829, offered a premium of $4,000 for the best American locomotive.

At this period in this history more mind and more practical skill has been brought out in Philadelphia, looking towards the improvement of the locomotive engine. In March, 1830, Col. Stephen H. Long, of the United States Topographical Engineers, a gentleman of high scientific culture, and noted for his originality, obtained a charter from the State of Pennsylvania, incorporating the "American Steam Carriage Company," and soon thereafter commenced the construction of a locomotive in Philadelphia. This engine was designed somewhat after the then recently improved locomotives made in England, but had several original points.

This first engine of Col. Long was placed, when finished, upon the Newcastle and Frenchtown Railroad, and the Hon. Wm. D. Lewis has furnished the following account of its trial at various times on that road with which he at that time was connected in an official capacity.

COL. LONG'S LOCOMOTIVE.

"On the 4th of July, 1831, two miles of the rails being laid on the Newcastle and Frenchtown Railroad, Col. Long made trial on it of his locomotive, which weighed about 3½ tons. The first effort was not a success, the failure being attributed to lack of capacity to furnish a sufficient supply of steam. It would go well enough for a while, but the steam could not be kept up. The next day the Colonel had better luck; his engine then going to the end of our rails and back, drawing two passenger cars packed with people, (say 70 or 80,) with apparent ease, and it had fifty pounds of steam at the end of the experiment.

"The Colonel, however, was not satisfied with it, and the machine was brought to Philadelphia again, and a new boiler was constructed for it at Rush & Muhlenburgh's works at Bush-hill. This engine was again taken to Newcastle and tried upon the road but it again failed. It would go very well for a time, but on the 31st of October, 1831, a pipe was burst and it became disabled. This being repaired, two days thereafter another trial was made, but with equal want of success, which was ascribed to lack of power, as well as of specific gravity. Alone, this engine went very well, and rapidly, say at the rate of 25 miles an hour, but it would not draw a satisfactory burden.

"Soon after the above date, Col. Long removed his engine from the road, and I do not know what became of it afterwards." Mr. Lewis adds, "The above memoranda I now enclose of the trials of Col. Long's locomotive in 1831, are made from a book in which all the facts I give you were set down contemporaneously with their occurrence." This unsuccessful attempt of Col. Long was, up to its date, much the most important movement that had yet been made in Philadelphia towards the improvement of the locomotive, and as such it deserves special notice. It was furthermore not without its value in inducing him to pursue the subject to much better results. Had Col. Long more faithfully copied the English engine of his day, he would have had better success in his first effort; but he, as with all our Philadelphia engineers and mechanics at that time, and in the succeeding years, aimed at making an American locomotive.

Whilst Col. Long was engaged in the construction of his engine,

the late Matthias W. Baldwin, a name that has since become so famous in the history of the improvements and in the manufacture of the locomotive in Philadelphia, was engaged in making a model locomotive for the Philadelphia Museum. In this work Mr. Baldwin was assisted by that highly eminent practical mechanic and engineer, the late Franklin Peale, then Manager of the Museum.

To gratify the curiosity of the public to know more of this new thing, this little engine was placed upon a track laid around the rooms of the Museum, in what was then the Arcade, in Chestnut street above Sixth, and where it was first put in operation on April 25th, 1831. It made the circuit of the Museum rooms many times during the day and evening for several months, drawing behind it two miniature passenger cars, with seats in each for four persons, but often carrying twice that number, in a manner highly gratifying to the public, who attended in crowds to witness for the first time in this city and State the effect of steam in railroad transportation.

The desire to *know* more of, and the necessity to *have* as speedily as possible, this new power, soon became a paramount question in the Middle, Northern and Fastern States of the Union.

The reward of $4000 offered for the best American Locomotive by the Directors of the Baltimore and Ohio Railroad, brought out many competitors, and in after years several very curious specimens of locomotive engineering might be seen in one of the shops of this road. An eye-witness of these efforts in 1834, describes one which sported two walking-beams precisely like the river steamers of the present day. Mr. Phineas Davis, of York, Pennsylvania, bore off the prize offered by the Baltimore and Ohio Railroad, and his engine was the only one that survived the trial. With the Peter Cooper upright tubular boiler adapted thereto, this locomotive of Mr. Davis became for several years the type of engine for the road upon which it won its fame, and to this day some of these Grasshopper or Crab engines, as they are sometimes called, may be seen doing good service at the Camden street Station, in Baltimore.*

*Previous to the competition on the Baltimore Railroad, Mr. Peter Cooper, the well-known New York Philanthropist of the present day, sent to Baltimore a small engine not larger than an ordinary hand-car. This little locomotive had an upright tubular boiler, (no doubt the first of its kind,) which developed such good steam-making qualities as to induce Mr. Phineas Davis to purchase the Cooper patent right, and boilers of this kind were used by Mr. Davis in the locomotives built by him, subsequent to the competitive trial on the Baltimore and Ohio Railroad.

REPORT OF WATER-WHEEL TESTS AT LOWELL AND OTHER PLACES.

By James Emerson, Lowell, Mass.

Early in the past season, notice was given that the experiments at the Lowell Testing Flume would close for the season with November; but at that date twenty wheels remained untried, and the experiments were continued until the close of the year; then, to decide whether the percentage of a wheel remained the same under different heads, I went to Ballston Spa, N. Y., and Mount Holly, N. J., and tested wheels that had previously been tested here. The results obtained seem to show that much higher percentage can be obtained under a low than a high head.

A description of all the wheels that I have tested would require too much room, and I will only refer to the peculiarities of a few. There seems to be a growing mania with wheel-builders to construct combination, or double wheels. The idea, old in itself, seems to have been revived by James Leffel at a time when it was difficult to find a really good wheel. The merits of his wheel, together with the indomitable energy of its builders, have rendered it one of the leading wheels in the country and too well known to require description here.

The combination shown in fig. 3 is upon an entirely different principle—a "perpetual motion," if successful. This combination was placed in a curb similar to the one patented by W. S. Davis, only the gates all opened at once. Mr. Wynkoop claimed that the velocity of the water, by direct action, operated the upper wheel, then the *weight* of the water acted upon the re-action wheel below, thus obtaining double power from the water used; and, strange as it may seem, college professors, engineers, high school teachers and officials of various grades were found who were willing to endorse such claims; and a circular was published and circulated, containing the names of a score or more of influential persons, who stated that they had seen the wheel in operation, and believed it gave one hundred and seventy-five if not two hundred per cent. of the power of the water used. When the combination was tested here it discharged so much more water than was expected, that the weir was too short and the water ran over the sides of the testing pit. The percentage due from the water passing the weir without allowance for that escaping over the sides of the pit, is given with the other wheels. Since testing the combination, I have received applications from three different States, by different parties,

for terms for testing identically the same combination. An engraving of the Wynkoop, together with the results of test sent in reply, has in each case closed the correspondence.

A combination of the "Barker Mill," with a Fourneyron wheel, as represented (fig. 4), also has admirers. Three Mexicans from the City of Mexico came here to have such a combination tested, but abandoned it before doing so. The same combination has been placed in a mill within a few miles of this city, but the inventor has not yet concluded to enlarge his building facilities.

B. J. Barber of Ballston Spa, N. Y., has made a combination that works well (fig. 5); so well, indeed, as to cause manufacturers to think seriously of exchanging the expensive Fourneyron wheels as built by Mr. Boyden for it. The combination consists of a wheel like the Warren, (which was a favorite fifteen years ago, and now may be seen back of many a mill in New England, where it has been thrown to make room for better wheels,) and a re-action wheel underneath for the purpose of utilizing the remaining power of the water after it has passed the upper wheel. This is a theory upon which much time and money has been expended. Mr. Barber is working upon a more decisive plan than theorists generally do, for he has built a testing flume and procured complete testing apparatus in order to work understandingly.

Stilwell & Bierce Manufacturing Company of Dayton, Ohio, have also done the same in order to make the Eclipse (double) Turbine one of the best.

Gardiner Cox also furnished a wheel which he called double; it consisted of a core with a Jonval wheel, around it, at the bottom, the buckets being continued by sheet iron spirals around the core to its top, forming a twelve-threaded screw; the pitch being twelve degrees from line of rotation.

The curb represented in fig. 6 was tried, to ascertain whether better "part gate" results could be obtained by opening a certain number of gates, from two to sixteen, than by opening the whole, proportionally; with the wheels tried, the results were not favorable, but the principle would seem to be correct, for in testing a Houston wheel, with some of the openings stopped with blocks of wood, it will be seen that very high results were obtained for the proportion of water used.

Much has been said about highly finished wheels being sent here for trial. There is little foundation for such rumors. In 1869 the Messrs. Leffel sent wheels that were constructed for the purpose, as

3.

The two wheels combined with gears
at the top, like the Wynkoop.

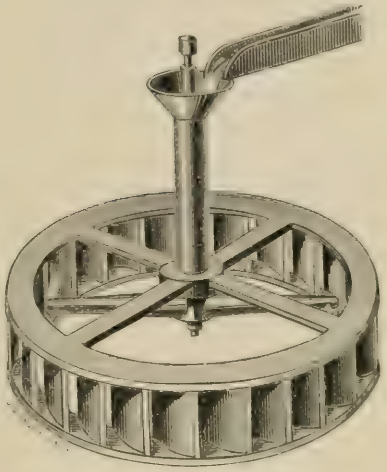


Fig. 4.

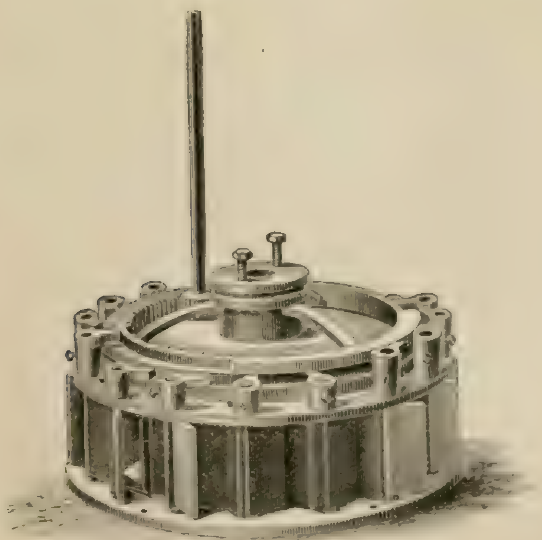


Fig. 6.

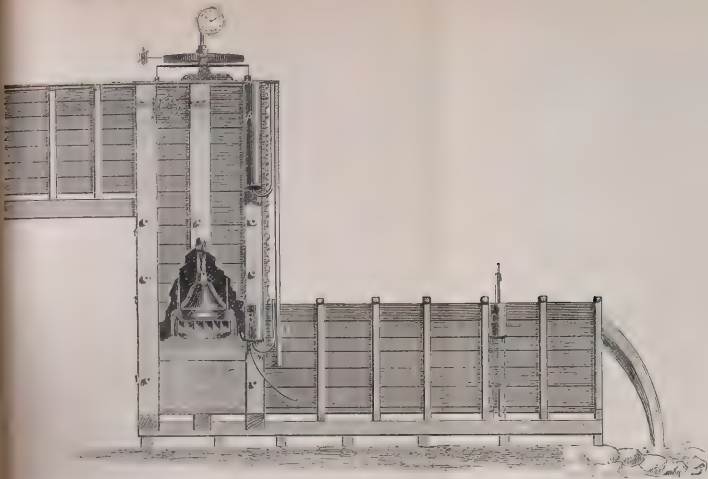


Fig. 1.

Fig. 3.

The two wheels combined with gears at the top, like the Wynkoop.

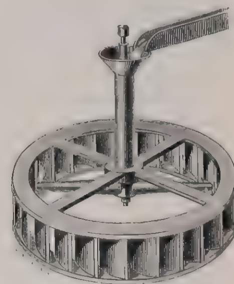


Fig. 4.

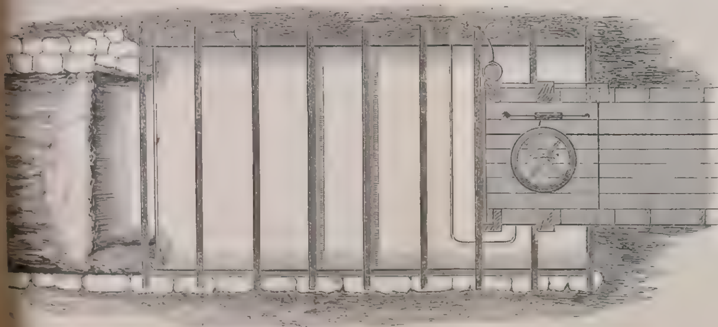


Fig. 2.

Fig. 5.

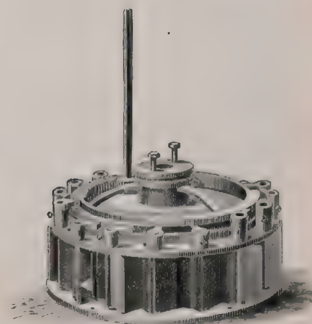


Fig. 6.

they had a right to do under the conditions imposed, and, as a rule, those sending wheels have been very fair, and, most certainly, the wheels that have given the best results have not been those of the best finish. It is quite common for some manufacturers to say that "little reliance can be placed in reports of tests;" such statements have a very injurious influence, and if there is any cause for such, it rests with themselves. The comparative merits of any wheel may be determined at a testing flume as perfectly as groceries can be weighed, but the cause for discrepancies is that builders seldom construct two wheels exactly alike, so that if Mr. Smith has a "Samson Turbine" that gives satisfactory results, there is no certainty that Mr. Jones will get one of that make that will do the same, and here may be found the cause why references are of little value. The better class of builders, feeling the inconveniences arising from such a system, are having their wheels tested, not only to determine their merits, but experimentally for improvement, while another class sell their wheels on the reputation of some well-known wheel that has been tested, but the same builder while experimenting will vary more than twenty per cent., consequently, manufacturers should understand that a resemblance is no guarantee of merit, and their only chance for obtaining a reliable wheel is to buy of responsible parties who are ready, at any time, to prove by actual trial that their wheels are what they are represented to be; a strict observance of such a rule would add at least twenty-five per cent. useful effect to the water power of Massachusetts.

An examination of the results obtained while testing N. F. Burnham's wheel will show the accuracy with which it can be done. The wheel was first tested, the shaft being made rigid with faced couplings bolted together; it was then taken out, the face couplings exchanged for clutch couplings, then tested again, afterwards taken out of the flume, then taken apart, the buckets filled to an edge, faced couplings again fitted on and the shaft where it worked in the upper bearing filed smaller, then tested the third time.

Stetson's first wheel, tested 1870, was tested the past season to decide whether a decked Flume is equally as effective as an open flume; it will be seen that the highest result was obtained in the decked flume, but it had four hundred pounds less weight of shafting to carry.

In making the experiments to determine the loss of power in transmission through gears, mitre gears twenty-seven inches in diameter, five-inch face, fifty-seven teeth, were used on wheel and "jack-shaft,"

the last being six feet in length and three inches in diameter, a spur gear twenty-four inches in diameter, four and one-half inch face, forty-four teeth, was secured upon the "jack-shaft,' which worked into another gear of the same size upon a second horizontal shaft, same size and and length as the first, the second representing the main line of shafting through a mill, both horizontal shafts worked in common babbited bearings. The dynamometer was placed upon the end of the shaft representing the main line, and the wheel tested through the two pairs of gears; the second shaft was then removed, the dynamometer applied to the end of the "jack-shaft," and the wheel was then tested through the mitre gears only, then the "jack-shaft" was removed, the gear taken from the top of the wheel shaft, the dynamometer applied at the same point and the wheel tested in the usual manner; the tests upon the wheel shaft and the shaft representing the main line were perfectly steady and reliable. The test upon the "jack-shaft" was made at noon under a higher head, and the end of the shaft was too small for the hub of the dynamometer, causing it to run eccentrically, and the test was not so good. I propose the coming season to make a more thorough trial of such tests with differently proportioned gears.

The reported part gate tests were taken when the wheels were running at about the same speed as when the best whole gate results were obtained; and three-fourths, one-half, one-fourth, &c., gate designate the proportions of water discharged and not the openings of the gate.

TEST OF WHEEL TO DETERMINE LOSS OF POWER IN TRANSMISSION THROUGH GEARS.

Through a pair of mitre and a pair of spurs, as described, the brake being placed upon the end of the second horizontal shaft, then upon the first horizontal shaft, then upon the wheel shaft.

Tests.	Head.	Revolutions.	Horse Power.	Percentage.
1st test.	16·03 feet.	160 per minute.	26·55	75·90
2d "	16·64 "	172 " "	27·36	74.80
3d "	16·08 "	168 " "	26·72	77·40

OUTSIDE TESTS FOR POWER ONLY.

Chase Wheel, Orange, Mass. Have tested four different wheels; one guaranteed to give 30 horse power, gave 11·8; but as a general

thing they gave about the power rated, using enormous quantities of water. The tables in their circulars are computed at about 90 per cent., and the discharge of the wheel is estimated from its openings, but the centrifugal force causes a discharge considerably larger than would pass through the wheel when it is at rest (ascertained by actual trial). The wheel, under favorable circumstances, gives about 50 per cent. of the power of the water used.

Whitney Wheel, at South Lancaster, Mass. Tabled horse power under 7-foot head, 66·17. Actual, as per test, 35·65.

Whitney Four-Feet Scroll Wheel, at C. B. Richmond's Mill, Lowell, Mass. Guaranteed, under 8-foot head, to give 20 horse power. Actual, as per test, under 8-foot 5-inch head, 11·22. Four-Feet Flume Wheel, same mill, 8-foot head, gave 15 horse power.

Five-Feet Blake Wheel, at same mill. Guaranteed, under 8-foot head, to give 30 horse power. Actual, as per test, under 7-foot 8-inch head, 15.

Seventy-two-Inch Reynold's, at Williamstown, Mass. Tabled, under 12-foot 3-inch head, to give 152 horse power. Actual, as per test, 76·97. Nominal percentage, as per table, 95. Actual, about 50.

July 26, 1871, I assisted in testing the same wheel again, after submerging it. Dynamometer placed upon wheel shaft, 12-foot head gave 88·30 horse power. Saw no reason to change my opinion about the percentage of that wheel, at any rate.

Breast Wheel, at North Adams, Mass. Diameter, 16 feet; length, 22; head, 14. Best result, 52·67 horse power.

I have, in the first part of my Report, alluded to tests made at Ballston Spa, N. Y., and Mount Holly, N. J. Those tests show very high results, and if the correction in Mr. Francis' formula for velocity of water approaching the weir is reliable, then low falls give proportionally much the best results. I have never seen experiments made where the brake worked so smoothly as at Mount Holly. Under the six-foot head, the wheel ran so steady that the hydraulic regulator upon the scale beam was hardly required, and when the wheel was running at its best speed, the water near the weir might have been used for a mirror, it was running so smooth.

At Ballston Spa, Mr. Barber's wheel gave, with the upper wheel tested alone, five per cent. higher results than at Lowell; while with the two combined, the best result was about seventy-nine and a half; this was under eight-feet head. The test of the combined wheels at Lowell can not be considered reliable, because it was bound in the

stuffing-box. The Risdon wheel was also bound slightly in the upper bearing at Lowell, causing a loss perhaps of one per cent., while it run perfectly free at Mount Holly, where it gave 84·24 as highest result. Now, it must be understood that I consider the Risdon or Barber wheel exceptional, for that is far from being the case, for I believe the other wheels tested would show the same proportional results under low heads, and to determine that point, I shall immediately construct a new flume that will enable me to test all wheels under from six to eighteen-foot head, and I propose to have my flume large enough to test five foot wheels. I test wheels that give good percentage that I should not consider so good for practical use as others that perhaps show in my Report less favorably; but it is not expected that I should discriminate, but give figures only, as I do; but it is for the interest of those using wheels that a matter of such importance should be definitely determined; for that reason I make the following proposition: The first day of September next I will have flume and apparatus complete for testing large wheels under varying heads, the trial to be open to all, each wheel-builder to furnish one or more forty-eight or fifty-inch wheel, to be delivered at my flume upon the day named, and each party to be there ready to choose a committee competent to examine and witness the test of each wheel, and let the decision of that committee be published throughout the country; and I here call upon the Messrs. Swain, Leffel, Bodine, Bryson, Houston, Stetson, Burnham, Libby, Risdon, Wheeler, Cook, Barber and others, to demonstrate, by a thorough competitive trial, where the conditions are the same for all, that they have faith in their assertions that *their wheel is the best.*

Particulars for terms, conditions, &c., may be had upon application.

Lowell, Mass., Box 502, *February* 1*st*, 1872.

EXPERIMENTAL STEAM BOILER EXPLOSIONS.

Discussion of the third experiment at Sandy Hook, New York.

By Prof. R. H. Thurston.

The violence with which the third boiler, experimented upon at Sandy Hook, exploded, has raised a doubt in the minds of many engineers whether some extraordinary and unfamiliar cause may not have operated in the production of such astonishing effects. No positive proof of the non-existence of such causes can be given, but the following considerations will at least indicate that we may find,

1

NAM

Swain ....
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" ....
" ....
" .....
" .....
Leffel.....
Common
Bodine J
Bryson T
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Tice ....
Houston.
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Second...
" ...
Third......
" ......
" ......
Trullinge
Second...
Kindlebe
Stetson ..
" ..
Second...
Same......
Another..
Same. .....
Upham...
Second....
" ....
Third......
Fourth....
Fifth.......
Sixth ......
Seventh..
Luther....
" ....
Wheeler..
Second ...
Third......
Whitney..
Second....
Third......
" ......
Wynkoop
"
Davis......
Second....
Third....
Tyler.......
" ....
Second. ..
Third......
Burnham
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Buzby ....
Cook.......
Second....
Bastion....
Second....
Third......
Risdon....
" ....
" ....
Eclipse...
Barber ....
" ...
Teller ....
" ...
Libby .....
Second....
Third......
Gardiner
Thompso

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NAME	Size.	REMARKS.	Ft. Head.	PERCENTAGE OF PART GATE. $\frac{1}{4}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	WHOLE GATE. Horse-Power.	Per cent.
Swain	42 in.	In "Quarter turn".	14·25						63·60	82·2
"	36	" " "	15·10						46·39	77·56
"	36	Wood Flume	15·10	13·10	43·20		67·00	71·90	45·40	74·60
"	30	" "	15·41		47·30	59·20	59·20	72·80	36·40	76·17
"	24	"Quarter turn"	16·66		54·17		72·30		24·26	77·69
"	24	Wood Flume	15·89		55·40		67·61	72·90	18·07	72·60
Leffel	40	Iron Case, extra finish, expressly for test.							42·00	79·70
Common finish	30½	Wood Flume	15·40		53·10	64·80	66·40	67·50	31·82	74·80
Bodine Jonval	35	Iron Case	14·70						34·00	75·90
Bryson Turret	42	Wood Flume	14·00							75·14
" "	30	Iron Case	14·51						26·00	74·10
Tice	30	Wood Flume.								
Houston	31	" "	[illegible]						11·25	82·30
"	35	" "	15·50						41·28	79·04
Second	35	Iron Case. Ice in flume and on weir.	14·95						37·36	77·50
"	30	" " " " "	[illegible]·80						26·81	78·80
Third	30	Wood Flume.	15·00		45·50	48·60	60·90	65·00	29·45	81·21
"	30	With four guides stopped with blocks of wood							22·72	76·00
"	30	With seven, or one-half the openings stopped, discharging a little more than half water							15·76	70·30
Trullinger	30	Brass Buckets, bound in curb and burst	15·69						19·31	50·64
Second	30	Iron Buckets. No reliable part gate	15·80						27·78	70·37
Kindleberger	25		15·30						25·22	62·46
Stetson	30	Open Flume—1870	15·79				71·60		25·72	78·46
"	30	In Decked Flume—1871	15·09		56·84		72·83		26·13	79·26
Second	30	Deeper, greater discharge	16·17						29·32	74·10
Same	30	Suspended by the neck	16·07		55·76		70·36		27·17	75·70
Another	30	Like the above, with one bucket less	16·00		55·41		71·79		29·61	77·40
Same	30	Suspended by the neck	14·76						26·82	79·08
Upham	36	Wood Flume, bound in curb & crumbled to pieces	15·99						18·32	52·08
Second	36	" " Same curb bound badly	[illegible]·59						22·06	58·82
"	36	Scroll	15·85						26·53	72·84
Third	36	Wood Flume. Bound in curb	[illegible]·64						17·11	53·78
Fourth	36	" " Less No. of buckets than the above	16·52						18·96	6[illegible]·03
Fifth	36	Scroll. Scroll 1¼ in. in depth less than the above	16·38						20·05	64·09
Sixth	36	Less buckets. The 4 wheels made with plates at top	16·38						20·05	64·09
Seventh	36	First Scroll Wheel made with arms, openings between tested in reduced scroll	16·31						22·28	67·42
Luther	30	Scroll Wheel	16·10						18·01	70·51
"	16	Discharged so little water that it would not carry brake								
Wheeler	36		15·65				66·90		27·73	74·50
Second	36		16·10		61·56		70·62		29·63	74·46
Third	36		15·61						25·56	67·61
Whitney	30		15·28						23·48	67·13
Second	30	Greater discharge	15·71						23·79	
Third	30	Three less buckets. Results better than with more	15·66						27·97	
"	18	Sliding gates	15·15						11·70	
Wynkoop	42		15·12						36·22	[illegible]
"	42	Cut hole in draft tube. Large quantity of water escaped unmeasured	16·90						21·88	[illegible]
Davis	36	See his patent curb. Wheel burst after running a few minutes	16·30						30·97	[illegible]
Second	36	Curb tried for part gate tests, but nothing seemed gained by the arrangement	15·17						36·42	68·56
Third	36	Like the Warren	15·48						[illegible]	63·46
Tyler	42	In use six years	15·20						[illegible]	75·56
"	[illegible]	New, none sold	15·70		38·11		[illegible]		27·13	73·83
Second	30	Old style, wrought iron buckets	15·69						[illegible]	67·04
Third	30	Old style, cast whole, cast iron buckets	15·53						25·06	67·01
Burnham	24		15·40		48·16		64·13	71·95	19·71	77·09
"	[illegible]	Tested with rigid shaft	15·27		[illegible]	54·60		[illegible]	42·18	78·60
"	[illegible]	Clutch couplings used	[illegible]						43·27	78·50
"	[illegible]	Rigid couplings. Buckets and shaft filed	15·42						43·27	79·20
[illegible]	[illegible]		14·97	15·92	[illegible]		58·51	[illegible]	24·10	[illegible]
Cook	[illegible]	Buckets changeable	15·70		56·78		67·92		27·53	73·11
Second	30	Double buckets	14·71		66·40		[illegible]	73·20	28·14	72·40
[illegible]	30	Intended to be like Houston's	16·25		29·51		[illegible]		18·01	66·75
Second	[illegible]	Wicket Gate	16·10				31·40		27·64	69·71
Third	30	" "	16·00		[illegible]		34·60		[illegible]	70·10
Risdon	30	With diffuser on. Diffuser was a flaring tube underneath	15·79						[illegible]	77·00
"	30	Diffuser off	15·98		[illegible]		66·59		27·42	77·14
"	36		15·92		41·17	[illegible]	69·02	76·12	36·57	78·71
Eclipse	24	Experimental, to determine effect of changes								
Barber	30	Combination two wheels—test of upper wheel alone	15·97						21·78	66·36
"	30	Test of the two combined	[illegible]						26·39	68·43
Teller	[illegible]	Double wheel	14·78						27·27	64·50
"	21	" "	[illegible]						29·64	[illegible]
Libby	30	An inverted Houston's	15·36		11·50		41·42	48·88	[illegible]	75·61
Second	30		[illegible]						[illegible]	[illegible]
Third	30		15·42						27·13	77·89
Gardiner Cox	30	Double spiral and Jonval	11·87		[illegible]		64·50	69·50	[illegible]	[illegible]
Thompson	30	Somewhat like Houston's	16·87		[illegible]		68·50	69·10	24·50	72·00

in well understood and certainly existing causes, ample power to produce all of the effects noted.

The steam boiler referred to weighed 40,000 pounds, and contained about 30,000 pounds of water and 150 pounds of steam, all of which had a temperature of 301° Fahr., when, at the moment before explosion, the steam pressure was $53\frac{1}{2}$ pounds above that of the atmosphere.

When the explosion took place, the whole mass at once liberated its heat, until it had cooled down to the temperature of vapor under the pressure of the atmosphere.

In this act the water gave off $30{,}000 \times 89° = 2{,}670{,}000$ British thermal units, and the steam lost the difference between its total heat at 301° and that of 212° Fahr., or $150 \times 27{\cdot}2° = 4080$ thermal units. The sum, $2{,}670{,}000 + 4080 = 2{,}674{,}080$ thermal units has an equivalent in mechanical energy of $2{,}674{,}080 \times 772 = 2{,}064{,}389{,}760$ foot-pounds, and this was sufficient to have raised the whole boiler and contents, weighing 70,000 pounds, to a height of 29,491.282 feet—*more than five miles.* This represents the *maximum* possible effect.

The *least* effect would have been produced had the liberation of heat and the production of additional quantities of steam, within the mass of water and at its surface, been so sluggish as to have given no assistance in propelling the fragments of the ruptured boiler,—the whole destructive work being done by the simple expansion of the steam which filled the steam spaces.

The total amount of mechanical energy set free from the steam alone, was $4{,}080 \times 772 = 3{,}149{,}760$ foot-pounds, or sufficient to raise the whole boiler through a space of 78·74 feet, and, water included, 44.99 feet. Owing to the greater inertia of the lower part of the boiler, and particularly of its inelastic burden of water, the principal part of this work was undoubtedly performed upon the upper portion and steam chimney of the boiler, weighing, probably, 6,000 pounds; and, if entirely expended in this direction, the work thus done was equivalent to raising this 6,000 pounds to a height of 525 feet.

This latter case is capable of treatment in quite a different way from the above. As the boiler was completely torn in pieces, the steam must have expanded pretty equally in all directions, except where checked in its downward movement, and may probably be treated as if forming a rapidly expanding hemisphere of vapor, its centre being in the steam space of the boiler.

The expansion of this hemisphere would have continued until the

tension of the steam was reduced to that of the surrounding atmosphere, and would have continued through a mean distance, as given by an approximate estimate, of 4·5 feet. The mean pressure would be 25 pounds above the atmosphere nearly.

The area of cross-section of the steam drum was 4,071 square inches, and $4{,}071 \times 25 \times 4{\cdot}5 = 457{,}987{\cdot}5$ foot-pounds, the amount of work done in its projection.

The weight of the steam drum, which was one-quarter inch thick, six feet diameter, and eight feet eight inches high, was, with its braces, 2,500 pounds, and $457{,}987{\cdot}5 \div 2{,}500 = 183{\cdot}2$, the height, in feet, to which the drum might have been thrown by the simple expansion of the confined steam. In fact, the steam drum had attached to it, when found after the explosion, a considerable part of the boiler top, which, being comparatively light, and being acted upon by similar pressures, must have considerably accelerated, rather than retarded, its ascent.

Still another calculation may be based upon the observed effects of this explosion. The steam drum was observed to rise at a high "angle of elevation," and fell at a distance of 450 feet from the starting point.

If this angle of elevation was 60°—and the general impression was that it was not less—the height due to the range, 450 feet, neglecting the resistance of the air, would have been

$$h = \frac{R}{2 \sin 2a} = \frac{450}{2 \times .866} = 260 \text{ feet.}$$

The retarding effect of the atmosphere causes our figure to be somewhat less than the true value, and it may be more nearly correct to take 275 feet as the height due to the noted range. The work done in raising the steam drum to this height was 687,500 foot-pounds, and the pressure which, acting through a space of 4·5 feet upon the base, would correspond to this amount of work, is 37·5 pounds.

This figure is in excess of the real pressure required, for the reason, as already stated, that a part of the shell was attached to the steam drum, assisting in its propulsion to an extent which is a matter of mere conjecture, and which not improbably reduces the given pressure several pounds.

The actual height of ascent of this piece was variously estimated by the spectators at from 200 to 400 feet, and, by one individual at least, even considerably higher. As, in such cases, heights are usually over-estimated, the lower figure is most likely to be nearest the truth.

It would be impossible to make the last two estimates so closely approximate to accuracy as to entitle them to great confidence, and the other calculations are merely estimates of improbable actual effects.

The writer is, however, inclined to conclude :—

1st. That it is very certain that the energy of this explosion, and all of its tremendous effects, were principally due to the simple expansion of a mass of steam suddenly liberated, at a moderate pressure, by the general disruption of a steam boiler of very uniform but feeble strength.

2d. That, *in this case*, the liberation of steam throughout the mass of water contained in the boiler, and which took place by the evaporation of one pound in every thirteen of the water, and which resulted in setting free nearly seventy thousand cubic feet of steam, would not seem to have taken place promptly enough to greatly intensify the effects of the explosion.

3d. It would seem very doubtful whether Zerah Colburn's hypothesis—which explains the violent rupture of steam boilers, by the supposition that the steam liberated from the mass of water, in cases of explosion, carries with it, and violently projects against those parts of the shell immediately adjacent to the point of primary rupture, large quantities of water which, by their impact, extend the break and increase the destructive effect, can have had an illustration in case under consideration.

We have no right to conclude that such an action as Colburn described may not occur in many cases of explosion ; on the contrary, the simple experiment described in all text-books on Natural Philosophy, in which water in a closed vessel, and near the boiling point, is caused to enter into violent ebullition by the reduction of pressure following the application of cold to the upper part of the vessel, exhibits very plainly the probability of an action taking place such as Colburn describes.

The expulsion of the contents of a bottle of effervescent wine or fermented liquor, which occurs frequently on drawing the cork, is another illustration of such a phenomenon. There can hardly be a doubt that cases do occur in which the same action greatly increases the destructive effect of boiler explosions.

In the case above considered, it seems probable that the effect of the explosion was somewhat intensified by a generation of steam at and near the exterior of the mass of water contained in the boiler, but not by the expansion of steam formed near the centre of the mass.

Stevens' Institute of Technology, Hoboken, N. J., Jan., 1871.

PROBLEM OF THE RAFTERS.

By John C. Trautwine, Civ. Eng.

In my Civil Engineer's Pocket Book, pages 247 and 248, I proposed a mode of finding the strains on the uniformly loaded rafters, and upon the tie-beam of the simple roof truss, *a b c*. I also there stated that I considered the mode given by Professor Rankine, on page 470 of his Civil Engineering, edition of 1862, and by other authorities, as entirely erroneous and unsafe. In a foot-note on page 248, I gave the principle upon which my mode was based; and on page 252 I expressed the wish that "Professor de Volson Wood, or some one equally proficient in the higher branches of theoretical mechanics, would consider it worthy of an examination and opinion." Prof. Wood has kindly complied; and in the last number of the "Journal," under the head, "Problem of the Rafters," has shown that both the authorities and myself are in error; I to a greater extent than they, but fortunately on the safe side; whereas their method is, as I asserted, unsafe. My mode would be correct only for the action of a load placed at the top of the rafters, and omitting the weight of the rafters themselves. I am, however, inclined to think that Prof. Wood himself has also partially fallen into an error, to which allusion will be made farther on.

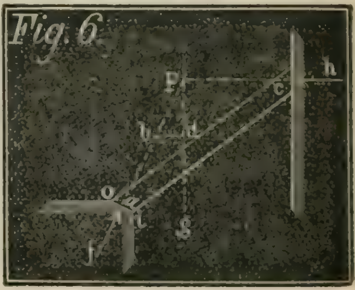
Unfortunately his paper is too mathematical for my perusal; and I can only express my regret that he did not employ such plain English as myself and readers generally understand, and which is amply sufficient for the elucidation of all such purely elementary principles. Still I learn from it that I am wrong in assuming that the loaded truss is to be regarded merely as so much weight resting upon its two supporting walls; but that it must be considered in the way pointed out for a single rafter in Art. 38 and fig. 22½ of my page 468, as given by Tredgold (see his Carpentry, edition of 1828, Art. 35, fig. 19), and later by Prof. Rankine.

However paradoxical it may at first sight appear that, so far as regards the strains, we must not primarily consider the truss as so much load pressing vertically upon its two supporting walls, yet such is the fact; and Prof. Wood has conferred a favor upon not only myself, but the profession in general, by directing attention to its application to truss, *a b c*. It is certainly strange that although the correct principle has been so long known, and so frequently employed in illustrating

the strains upon a single isolated rafter, yet it has invariably been overlooked when treating upon the two rafters of the simple truss; to each of which it applies *in precisely the same manner* as to the single one.

The correct method is thus expressed on my page 468:

"Let *a c*, figure $22\frac{1}{2}$, (fig. 6) be a beam; its foot resting on *o i*, and its head, *c*, merely *leaning against* a smooth *vertical* wall; and whether *a c* be unloaded, or whether it supports a load placed in any manner upon it or suspended from it, let the vertical line which passes through the centre of gravity of the beam and its load (both of which are supposed to be known) be represented by *p g*. The beam and its load may be regarded as a single body, acted upon and kept at rest by three forces, namely, its own gravity or weight, the force *h* at *c*, and the force *f* at *a*. No other forces act on it. Now, gravity acts vertically only, and in the case before us it may all be regarded as acting in the line *p g*. The force at *c* can act only at right angles to the surface or joint at that place (see Art. 19); and, since the joint is vertical, the force, *h*, must be horizontal, or along *h p*. The question now is, how to find the direction of the third force, *f*. To do this we must avail ourselves of the principle that when three forces which are not parallel to each other hold a body at rest, or in equilibrium, as these three forces hold the beam, *a c*, their directions all tend to or from one point, which is either at the centre of gravity of the body or in a vertical line passing through said centre. Hence, since the vertical direction, *p g*, of the force of gravity of the body, and the direction, *h p*, of the force, *h*, meet at *p*, therefore the direction, *f p*, of the force, *f*, must also meet there. Hence, we have only to draw a line, *f p*, in order to find the required direction. A post intended to support the end, *a*, of the beam, should have the position *f a*; and the joint, *o i*, should be at right angles to *f a*, and not to *a c*, as might at first be supposed from figs. 13 and 16 of Art. 32, in which the weight of the beams is not considered."



"Having found the directions of the three forces in fig. $22\frac{1}{2}$, it only remains to find their amounts. To do this, we already have one of them given, namely, gravity, or the weight of the beam and its load; and we know that they must be in proportion to the sides of the tri-

angle drawn parallel to their directions. Consequently, if on the vertical direction, *p g*, we lay off by scale any portion whatever, as *p d*, to represent the force of gravity, then will the horizontal side of the triangle, *p d b*, represent by the same scale the horizontal pressure at *c*; and the side, *b p*, the oblique pressure at *a*. The horizontal pressure at the foot is equal to that at the head of the beam. It is, of course, included in the oblique pressure, *f*, which is compounded of said horizontal force and of the vertical force at *a*. The vertical force is equal to the weight of the beam and its load, none of which is sustained at *c*, nor can be so long as the joint at the head and wall is vertical."

The *p a* of fig. 22½ must be used, instead of the *r a* on the figure of my page 247, to express the direction and amount of pressure at the foot of each rafter; and *p c* instead of my *r h* for the horizontal forces at their heads and feet.

This correct process always makes the horizontal pressure at the head of the uniformly loaded rafter of the simple truss, *a b c*, or the equal horizontal pull upon the tie-beam at its foot, precisely one-half of that given by my incorrect process.* It also makes the pressure, *p a*, at the foot of each rafter, less than mine, in the same proportion that *p a* in any given case is shorter than the rafter, *c a*, itself.

The point in which I now differ from Prof. Wood is this: I consider that the strain at the heads of the rafters is purely horizontal, and that there is no strain whatever in the direction *c a*, fig. 22½, or *o c* of this figure, of the length of a uniformly loaded rafter; whereas he and all the authorities maintain that there is such a strain at its head.

* In a foot-note to my page 259 I express the belief (based upon the same incorrect reasoning) that the authorities are altogether mistaken about the additional strain produced on the tie-rod of a truss when the rod is raised in the center instead of being horizontal. It follows from the above that I am wrong in this matter also, my proposed mode of finding the entire strain on a raised tie being in excess except for the action of a load at the top of the rafters, and omitting their weight. The authorities, also, I imagine, are necessarily mistaken here, as well as in the above case of their supposed longitudinal strains along the uniformly loaded rafters of the simple truss, *a b c*. If so, it follows that nothing reliable has hitherto been written on this subject.

I, with many others, should be glad to see this matter of raised tie-bars for uniformly loaded rafters treated in familiar language, aided by diagrams. *This* question becomes complicated by the necessity for recognizing a force in the direction *p b* of the first figure, in *addition* to one along the rafters, produced by raising the tie-bar.

If so, it must extend all the way to the foot; and we should have the weight of the rafter in the preceding figure equivalent, not to its two components, *h p* and *p o* alone, but to them and a third force in the direction of the rafter; and this I conceive to be inadmissible.

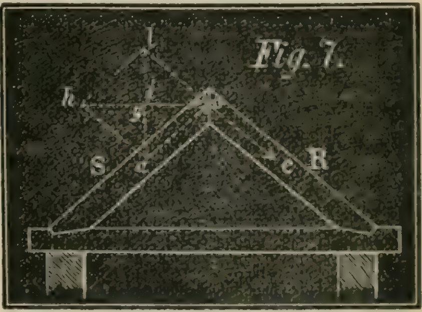


Fig. 7.

Prof. Wood reasons thus: The horizontal force, *h o*, pressing against the head of the rafter, R, may be conceived to be replaced by its two components, *l o* and *a o;* and *therefore* there is a strain, *o c*, equal to *l o*, at the head of the rafter. I, on the other hand, imagine that if, instead of the horizontal force, *h o*, we should apply the force, *l o*, *alone*, there would result, of course, a pressure, *o c*, along the rafter; but the moment we apply the other component, *a o*, at the same time, the direction of *l o* changes; and *l o* combining with *a o*, the two form a single new force, *h o*, the direction of which is *wholly horizontal.* The force, *l o*, may be conceived to be compounded of two forces equal to *li* and *io;* and the force, *a o*, of two equal to *a g* and *g o*. Now, if the two forces, *l o* and *a o*, be applied at the same point, *o*, at the same time, as substitutes for the single horizontal force, *h o*, I hold that their two equal vertical components, *l i* and *a g*, will re-act against or mutually *destroy* each other, leaving only the horizontal components, *i o* and *g o* (which are together equal to *h o*) to press as one single force against the rafter at *o*. In the same manner an opposite horizontal force equal to *h o* presses against the head of the rafter, S.

On my page 458, in Remarks 3 and 4, and in the Remark on page 450, I have endeavored to explain my views respecting this *mutual destruction* of *l i* and *a g* in the above figure in all cases of the conversion of two component forces into one resultant. I conceive that two components produce the same effect as their resultant, simply because equal portions of the two components *destroy* each other, so that the *remaining portions* actually *are* the resultant. In this I believe I am alone, for all writers appear to express the same views as Prof. Wood, and maintain that two components lose none of their energy by being applied at the same point at the same time. If I am wrong I shall be glad to be set right. My only desire in all such matters is to elicit *the truth.*

KEOKUK AND HAMILTON BRIDGE.

By Joseph S. Smith, Resident Engineer.

Organization.—February 13th, 1865, articles of incorporation for the construction of a railroad and wagon bridge were drawn up and approved under the name of the "Hancock County Bridge Company," with the following incorporators: Alexander Sympson, George Edmunds, Jr., Francis M. Corby, William A. Patterson, Hiram G. Ferris, Robert W. McClaughry, Andrew J. Griffith, Bryant T. Schofield and Phineas Kimball, Jr. Under this Act the company were privileged to bridge the Mississippi river at some point between the cities of Nauvoo and Warsaw, Hancock County, Illinois, to the Iowa shore, within the jurisdiction of the State of Illinois, and to commence operations within two years and complete the bridge within twenty years. Previous to this an Act was passed by the General Assembly of the State of Iowa, authorizing the construction of railroad bridges across the Missisippi and Missouri rivers, and was approved April 5th, 1864.

On January 15th, 1866, under the general incorporation law of the State of Iowa of 1851, Hugh T. Reid, James F. Cox, David W. Kilbourne, Robert F. Bower, Henry Strong, Smith Hamill, Wm. Leighton, Guy Wells, Carlton H. Perry, Henry H. Love, William Thompson and George C. Anderson incorporated themselves under the name of the Keokuk and Hamilton Mississippi Bridge Company, for the purpose of building a bridge across the Mississippi river as a railroad, wagon and foot passenger bridge, at or near the city of Keokuk, Lee County, Iowa, to a point at or near the city of Hamilton, Hancock County, Illinois, with power to unite with any bridge company chartered in the State of Illinois, with a capital stock of $1,000,000.

Under an Act of Congress of July 25th, 1866, bridges were authorized to be constructed at several points on the Mississippi and Missouri rivers, and established as Post Roads, of the number the Keokuk and Hamilton bridge.

Matters relating to a bridge at this point had now reached a stage when it became necessary to know the cost of the undertaking. A preliminary survey under the auspices of the Toledo, Wabash and Western Railway Co. had been made previous to1867, without leading to any definite results. In March, 1867, surveys were made by James W. Otley, Esq., Chief Engineer of the Des Moines Valley

Railroad, under the directions of Thomas Curtis Clark, Esq., then Engineer-in-Chief of the construction of the Quincy Railroad bridge. From this survey, preliminary plans were made and submitted to the city authorities of Keokuk early in 1868, upon which an ordinance, granting the right of way across the Levee, together with other privileges relating to the Union Depot Grounds, was passed and approved May 25th, 1868. Final plans, estimates and reports were submitted by Thomas Curtis Clarke, Esq., to the Directors of the Keokuk and Hamilton Mississippi Bridge Company in June, 1868.

On August 1st, 1868, the Hancock Co. B. Co. and the K. and H. Miss. B. Co. were consolidated under the name of the Keokuk and Hamilton Bridge Company, with the following Board of Directors: Hugh T. Reid, Carlton H. Perry, Wm. Leighton, David W. Kilbourne, Hugh W. Sample, Howard W. Perry, Hambden Buel, George W. McCrary and George E. Kilbourne, with a capital stock of $900,000, with power to raise it to $1,000,000.

The following were elected officers of the consolidated Company: Hugh T. Reid, President; Carlton H. Perry, Vice-President; Wm. Leighton, Secretary; Thomas Gilman, New York, Treasurer. Eastern capitalists were now solicited to undertake the construction of the bridge, and early in 1869 contracts were entered into with Andrew Carnegie and associates of Pennsylvania for its construction, to be commenced within thirty days and completed by the 1st January, 1870: based upon the plans of J. H. Linville, Esq., Civil Engineer of Philadelphia, as Chief Engineer for the bridge Co., with Thomas C. Clarke, Esq., C. E., late of the Quincy R. R. Bridge, as Consulting Engineer.

Mr. Joseph S. Smith, Resident Engineer in charge, together with his assistants, arrived on the ground early in March, 1869, together with the contractors for the substructure, Messrs. Quinn and Raynor, with their foremen and laborers. Having visited and examined several quarries for stone, contracts were closed with the Sonora Quarry Co., situated near Nauvoo, Hancock Co., Ills., it being the only quarry, within reasonable distance, so developed as to guarantee a supply as rapidly as would be required for the due completion of the masonry within the specified time. This stone is a magnesian limestone or dolomite, not difficult to work, but tough and durable, weighing about 148 lbs. per cubic foot. It has been thoroughly tested by geologists and others, and its use approved for the foundations of the State Capitol at Springfield, Illinois. That for the piers was nearly

all prepared during the season of 1869, and received further test by standing exposed until the building season of 1870.

Engineering.—Whilst the contractor was providing a steamer for the purpose of towing flat boats, derricks and other machinery, and all material to push the work rapidly, a final location of the bridge line was made, and its length across the river determined. A base line 3302.955 feet in length was established on the eastern shore, and carefully measured twice before the water got so high, (already covering portions of the base line about waist deep,) as to prevent the angles being taken at the lower end of the base. In establishing the base line, posts were planted solidly in the ground 20 feet apart, (the length of the measuring rods); on these were nailed cleats of 2 x 4 scantling, two feet in length set to a horizontal line with a levelling instrument. Three rods of well-seasoned pine lumber were made, their ends secured with brass tips planed off perfectly true, and care taken that each rod corresponded exactly in length with a standard furnished from the shops of the Keystone Bridge Company at Pittsburg. The first measurement of the base was 3302.975 feet, second one 3302.935 feet, the average of these was taken as above, their difference being under one-half inch. The angles were then taken, permanent monuments and ranges established. The triangle was a well proportioned one and nearly equilateral, the lengths of the sides being 3302.955 feet, 3579.722 and 3224.306 feet respectively. The angles were deduced by the repetition system, six observations being taken on each point. Levels were transferred to the eastern shore by equal sights of 2,100 feet each on a calm day, and closed within $\frac{1}{100}$ of a foot. Although the river was at a high stage during the month of May, being about 11 feet above low water of 1864, and not to delay operations when it should reach a stage suitable for erecting the piers, soundings were taken at each pier site. These showed the bed of the river to be at some points very uneven, and covered in many places with boulders of all sizes, coarse sand and gravel, and patches of sand varying in depth from six inches in the swifter current to eighteen inches and over as the pier sites approached the Illinois shore and the slack water behind the old Ferry dyke, but underlying all a good solid limestone rock bottom, affording one of the best crossings, as regards foundations, to be found on the Mississippi River, nevertheless demanding other measures to be devised for securing and protecting temporary works during the con-

struction of the piers, than is required where there is a sufficient depth of sand to hold piles.

Location.—The location of the bridge at the upper end of the levee, offers a minimum obstruction to navigation, inasmuch as Keokuk being the head of navigation for the St. Louis steamers, they do not pass above the bridge, having changed their landing place to a better point below; and the up-river steamers having lately adopted the safer method of dropping down stern first through the draw opening, are in much better position to reach their landing place.

The line established was practically the same as that determined from the surveys of 1867. It had then been found necessary to cross the river obliquely, to connect with the tracks of the Des Moines Valley R. R., and avoid using a curve of extremely short radius, also to not occupy any more than was unavoidable of the city levee along Water street. The terminal points are the same, but, in order to comply with the city ordinance, a street 66 feet in width was reserved along the face of the levee, which still further cramped the western approach to the bridge, and rendered necessary the present curve, unavoidable unless the approach could be carried further out into the river and thereby interfere materially with the proposed location of the draw span, and, of still greater importance, encroach too much on the water-way of the main channel, which would have a tendency to increase the velocity of the current, greatest at the Iowa shore, and to render the navigation of the draw spans more difficult to boats, especially those intending to enter the locks now being constructed above the bridge; or else the curve must be extended on to the draw span, which would have been more objectionable for several reasons. The western end of the bridge line commences in the D. V. R. R. tracks, nearly in the centre of Main street and seventy-one feet from the north face of Water street, curves to the right for 597 feet with a radius of 603·80 feet, on a rising grade of 61·25 feet per mile, then runs on a tangent of a nearly due west and east line 2972 feet, to a junction with the tracks of the Toledo, Peoria and Warsaw, and Toledo, Wabash and Western Railways, crossing the current of the river obliquely at an angle of 72° 45′, and descending from the eastern end of the superstructure on a grade of 85 feet per mile for 700 feet, a total length of track of 3569 feet, equal to $\frac{67}{100}$ of a mile.

Description of the Work-Approaches.—The western approach to the bridge consists first of an embankment, protected with a dry slope

wall 384 feet in length, which, for the convenience of the wagon road, slopes back with a macadamized surface from the levee opening and the railway track to the foot of Blondeau street, and extends along the face of Water street 250 feet. The levee opening of 20 feet on the square has two abutments set parallel with Water street, and contain $810\frac{1}{2}$ cubic yards of second class masonry. This opening is crossed with a plate girder for the railroad and a Pratt truss for the wagon road, each truss 38′ 6″ long on the skew. The second portion of the approach is of masonry, forming a cellular curved viaduct with 10 cross walls, being substituted for the embankment at the request of the city authorities; it is 211 feet in length by an average weight of $31\frac{1}{2}$ feet from the rock, with a width of 23 feet over the walls on top; side batir of walls is one in twelve. The superstructure of this is timber; the sidewalks are supported on cast-iron brackets outside the masonry, affording a total width over all of 34 feet, corresponding with the superstructure of the main bridge. Upon this superstructure the character of the whole bridge traffic begins to assume its proper shape, preparatory to crossing the river. The eastern approach is an embankment 750 feet long, 30 feet high at the abutment by 36 feet wide on top, well macadamized and protected with a dry slope wall to the top. Both approaches are fenced, and have gates to close the bridge to travel of all kinds, when the draw span is opened for the passage of boats. Ordinary traffic, it is true, will be impossible during the passage of trains, but as a train moving at the limited rate of six miles per hour would occupy less than seven minutes in crossing, this cannot be considered a serious objection for many years to come.

Piers.—There are fifteen piers of masonry, of which number thirteen stand in the river. In order that the piers should stand parallel with the thread of the current of the river, very careful observations of floats were taken with two iustruments, and the time of passage accurately noted. These observations being plotted, the direction of the current in regard to the bridge line was easily deduced and its velocity ascertained. The annexed table, showing the original flowage section and the amount cut off by the bridge, is as follows: water being a medium stage of 4′ 9″ above low water of 1864, the sections commencing at the Iowa shore and measured on the bridge line.

It is believed that the effect of the bridge will not increase the current over one half mile per hour above its present maximum velocity at any time.

Length of Section.	Velocity in feet per second.	Original area. sq. ft.	Discharge in cubic ft. per second.	Area cut off square feet.	Discharge cut off.	New area sq. ft.
610	4·16	5549	23·085	2319	9647	3230
540	5·00	5517	32·587	198	990	6319
470	4·08	4580	18·686	216	881	4364
580	2·90	5700	16·530	288	835	5412
680	2·00	2789	5·573	1979	3958	810
2820		24135	96·461	5000	16·311	20·135

The current and velocity on the eastern side of the river during the seasons of 1869 and 1870 was very much increased by the unfinished and unconnected state of the work of the canal on the rapids, rendering it still more difficult to do anything during a high stage of water.

Effects of Ice on the Piers.—The piers being set parallel to the thread of the current, make an angle with the bridge axis of 72° 45′, and the superstructure is built on a skew of 17° 15′. The bridge being located at the foot of the rapids will be, in a measure, protected from the ice when breaking up, as, at an ordinary stage of the river, it is very much broken up on the shoals of the rapids. It gorges sometimes on the rapids (but oftener below the city, backing the water up very high), and when the gorge breaks loose, the thrust from the ice on the piers will be very great, but not sufficient to endanger any of the piers. It is very certain that if ice were an unyielding substance, the momentum acquired by a field of ice from the velocity of the current coming off the rapids, would carry away any piers that could be built, but being of a yielding nature, it crushes to atoms as it is ploughed into by the piers' resistance, and the force of impact materially diminishes, and it comes to rest: if other fields still impel it forward, it climbs the nose of the pier and breaks into pieces from its own dead weight. It was ascertained, by experiments at Kansas City Bridge, that sound ice commences to crush under a pressure of 200 lbs. on the square inch, and is crushed to atoms when the pressure is 450 lbs. to the square inch. The hardest blue ice on the St. Lawrence river crushes under 300 lbs. to the square inch. We will, however, in this case, take the crushing pressure at 450 lbs. per square inch, that the ice goes out two feet thick on a stage of water eleven feet above low water of 1864, and that the pier consequently receives

the shock at the change of batir on the nose, being the most unfavorable condition. We have, for the crushing power, the pier being 7′·7″ thick at this point, $\frac{7'\cdot7'' \times 2' \times 144'' \times 450 \text{ lbs.}}{2000 \text{ lbs.}} = 496\cdot4$ tons. The momentum tending to overthrow the pier will be equal to this pressure multiplied by the height above the base, or $10' \times 496\cdot4$ tons $= 4964$ tons. The moment of stability to resist this overthrow will be the weight of the pier and truss multiplied by the half base length of the pier $= 665$ tons $\times 23'\ 8'' = 15.738$ tons.

To resist the sliding of one course on another, we have the weight of masonry above this point and truss, more than sufficient to prevent sliding, without taking into consideration the resistance due to the adhesion of the cement, or the advantage to be derived from the retreating form of the nose of the pier, which of itself would tend to decrease the force of the blow. We may then safely consider the piers as capable of resisting the impact of the ice at this point. This action of the ice was given due consideration, and a form of pier was chosen adapted to meet the requirements of this case, as well as to offer a minimum obstruction to the water-way of the river. The pier is long and narrow, the angle made by the two faces of the up-stream starling on a horizontal plane is a right angle, with a face batir of six inches in a foot vertical, giving the cutting edge of the pier a slope of about eight and one half inches in one foot rise for a height of ten feet above navigable low water, the remaining ten feet of the starling has a face batir of three inches, and a nose batir of nearly four and one quarter inches in a foot rise: The ice-breaker nose is projected with an angle iron $4'' \times 4'' \times \frac{1}{2}''$ extending the whole length of the starling and securely fastened to the masonry. The shoulder of the lower part of the starling is rounded off to a radius of thirty inches. The top of starling is the same elevation as the high water of 1851. The piers have a side batir of one in twenty-four, the down stream end circular with the same batir as the sides.

Dimensions of Piers.—The dimensions of the piers are as follows: The western rest pier is formed on the end of the western masonry approach, is $30'.\ 8'' \times 5'.\ 6''$ at lower end, and 10 feet 6″ at upper end, and is $35\frac{1}{2}$ feet high.

Pivot-pier and Protections.—Pivot-pier is circular with projections to receive the ends of the foundation cribbing between the upper and the lower draw rests, and the ends of the floats forming the protection to the draw span is 32 feet in diameter under the coping (with cross walls supporting a centre column 10×10 feet at the base, and 5′ 6″

square at the top, on which the centre of the draw span rests), and is 28 feet high, with a side batir of one in twenty-four. The upper and lower draw rests are of timber, having pockets filled with stone. The upper rest is provided with a cutting nose, sloping one-half to one for the first twelve feet above the foundation, and one-half to one for the remaining fourteen feet, protected with a 4″ × 4″ × ½″ angle iron as high as on the piers. The lower portion is also sheeted with $\frac{5}{16}$″ boiler plate on the faces and sides. The sides of this rest were 4″ × 10″ white oak plank, laid horizontally close together on the up-stream faces, but with open spaces on the sides and ends. The inside cross and longitudinal ties were of 2″ pine plank laid one over each other, and, dapped into the outer courses of oak, were spiked to it with ⅜ boat spikes, and to each other at the intersections with 6″ cut spike. The whole was sheeted vertically with six-inch white oak, well spiked on with ⅞ drifted bolts 12″ long. The lower draw rest is built of 4″ × 12″ pine plank with open spaces between, but sheeted vertically the same as upper rest. The foundation cribbing is of 12″ × 12″ pine, 34 feet wide over all, having pockets 8 ft. × 8 ft. on the outside only, and filled with stone. As the top of this cribbing is only four feet above low water, it will be under water during the greater portion of the navigable season; a float of white pine is therefore further provided, composed of two courses in height of 12 × 12 sticks on the outside, united with ties and diagonal bracing, and well sheeted with white oak plank 4″ thick. It is built in three divisions longitudinally; the outside ones being open, afford facilities to remove all débris deposited on the cribbing beneath during high water stages, and the inner one floored over to give more buoyancy; during the time of running ice it is calculated to rest on the cribbing, and its sides will offer a smooth surface. The floats are fitted with three cast-iron rollers at each end working on the projections of the pivot-pier and upper and lower draw rests, with sufficient play so that they can rise and fall freely with the water. East rest pier is 7 × 29 under coping, and 91 × 53′. 9″ on the foundation, and 36 feet high. The remaining nine piers are 6 × 29 feet under coping, and from 49′. 9″ to 52′. 8″ long by 9′. 11″ broad on the foundation, and an average height of 35 feet from the rock to the top of the coping. The eastern abutment has an L wing on the down stream side, and a circular sloping wing on the up stream side, with a radius of 32′ 3″. Total length of abutment 136′ 4″ by 12 feet wide on the foundations, finishes at 5′ 6″ on top, wings and face batir one in twenty-four.

(To be continued.)

PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

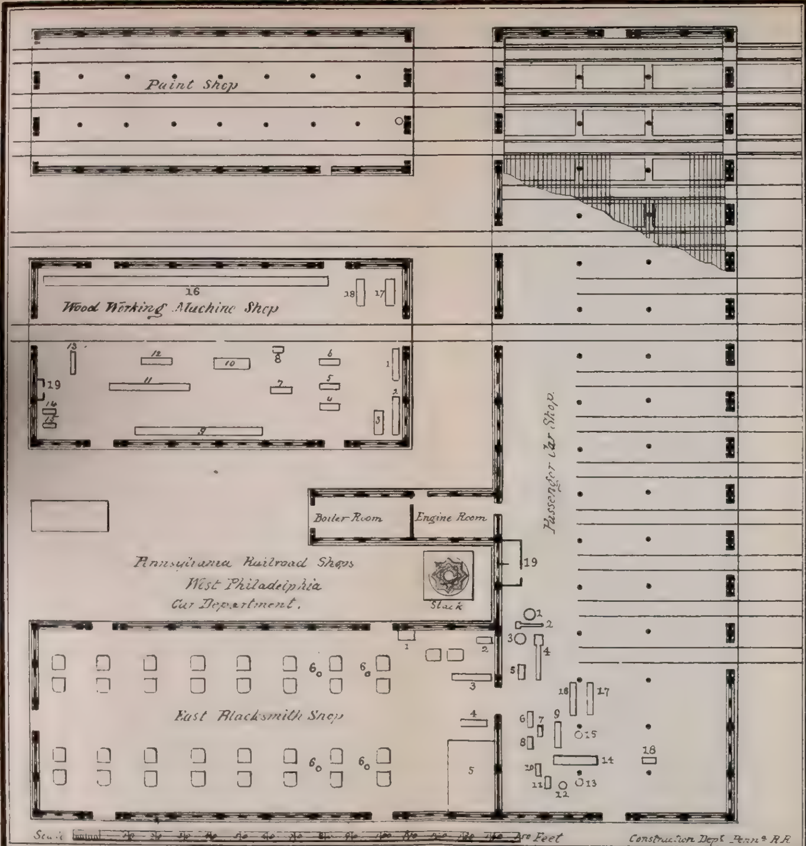
By Joseph M. Wilson, C. E.

P. A. Engineer Construction Department Pennsylvania Railroad.

(Continued from Vol LXII, page 320.)

Passenger-Car Shop.—This building, marked No. 9 on plate 1, is situated on the opposite side of the transfer pit from the locomotive and machine shop, and enjoys equally with it the advantages of the use of the table. The area of the building is the same as that of the locomotive and machine shop, viz., 280 feet 1½ inches long by 82 feet 8 inches wide, outside dimensions, and the details of construction are the same, except in respect to the roof. It contains tracks for fourteen cars, and although the whole of the area is floored over at present, the foundation walls have been arranged for pits at each of the tracks, so that the building may be readily changed into a locomotive shop whenever an increasing business demands it, and a new passenger-car shop be constructed on another site.

Plate XIV shows a plan of the shop. The roof is divided into three spans by two rows of cast-iron columns, and Plate XV gives a section through the building, showing the construction of the roof. The principals are placed 16 feet 4 inches apart, centre to centre, and the centre span is made much higher than the side spans, the arrangement being easily seen by reference to the plate. By this means a ventilator is formed the whole length of the roof, except on the end panel, the sides of the ventilator having glazed sash, hung to swing on centre and arranged to open and shut in sets, as done in the locomotive and machine shop. In the side spans the principal rafter is 10 by 10 inches section, and the tie beam 10 by 11 inches, and from this tie-beam is suspended the necessary shafting for running the machinery. In the centre span the principal rafters are 7 by 9 inches, and the tie-beam 7 by 12 inches section. The roof is braced longitudinally by trusses, one on each row of columns, extending up to and supporting the centre span of roof. The mode of connecting the side spans with these longitudinal trusses and the columns, and the lateral braces in the centre span, afford ample stiffness to the roof sideways. The purlins are five by eight inches section, placed three feet apart and securely fastened to the principals at intervals, by ⅝-inch bolts. The pitch of side roofs is 22 degrees, and of centre roof 14 degrees from the horizontal. The sheeting is the same as on the other roofs, and the slate is from the Peach Bottom quarries of Pennsylvania, size 10 by 20 inches, laid to weather 8½ inches. The


Paint Shop
16
18
17
Wood Working Machine Shop
Boiler Room
Engine Room
Passenger Car Shop.
Pennsylvania Railroad Shops
West Philadelphia
Car Department.
Stack
19
East Blacksmith Shop
Scale
Feet
Construction Dept. Penna R.R.

gutters, valleys and eave-pipes are of copper, gauge No. 24, and arranged in the same manner as on the other buildings.

The following is a list of the machinery in this shop:

No. 1. 33-inch Wheel Mill. Wm. Sellers & Co., makers.
" 2. Small Crane.
" 3. 33-inch Wheel Mill. " " "
" 4. Hydraulic Wheel Press. " " "
" 5. Nut Cutter. Made at W. P. Shops.
" 6. Screw Cutter. Bement & Dougherty, makers.
" 7. " " Wm. Sellers & Co., "
" 8. " " " " "
" 9. Turning Lathe, 16 inch swing. A. L. Archambault, maker.
" 10. Screw Cutter. Wm. Sellers & Co., makers.
" 11. " " " " "
" 12. Small Drill Press. Bement & Dougherty, makers.
" 13. Drill Press. Smith Beacock & Tannett, Leeds, England.
" 14. Planer. " " " " "
" 15. Drill Press. " " " " "
" 16. Axle Lathe. Bement & Dougherty, makers.
" 17. " " " "
" 18. Grindstone.

At No. 19 is a small office for the foreman of the shop, with a tool room adjoining. Along the walls are arranged work benches and closets for the workmen, in the same manner as in the locomotive and machine shop. There is an engine connected with this shop for running all the machinery in the car department, and the positions of engine and boiler rooms and stack, are shown in Plate XIV. The boiler is of the ordinary locomotive pattern, built at Altoona shops. The engine is a Corliss, 40 horse power, cylinder 12 inches diameter, three feet stroke. The band wheel is 12 feet diameter and ordinarily runs at 60 revolutions per minute. The stack is exactly the same as the one described previously.

East Blacksmith Shop.—This shop, No. 10 of Plate I, is connected with the passenger-car shop as shown on Plate XIV, and is intended for all blacksmith work required in the car department. It is of the same size as the west blacksmith shop, previously described, and built exactly the same, there being, however, 34 fires in this shop and only 24 in the other. In addition to these it contains

No. 1. Tempering Furnace.
" 2. No. 8 Dimpfel Patent Blower.
" 3. Trip Hammer.

No. 4. Punching Machine. Wm. Sellers & Co.
" 5. Iron Rack, for assorted sizes.
" 6. Small Cranes.

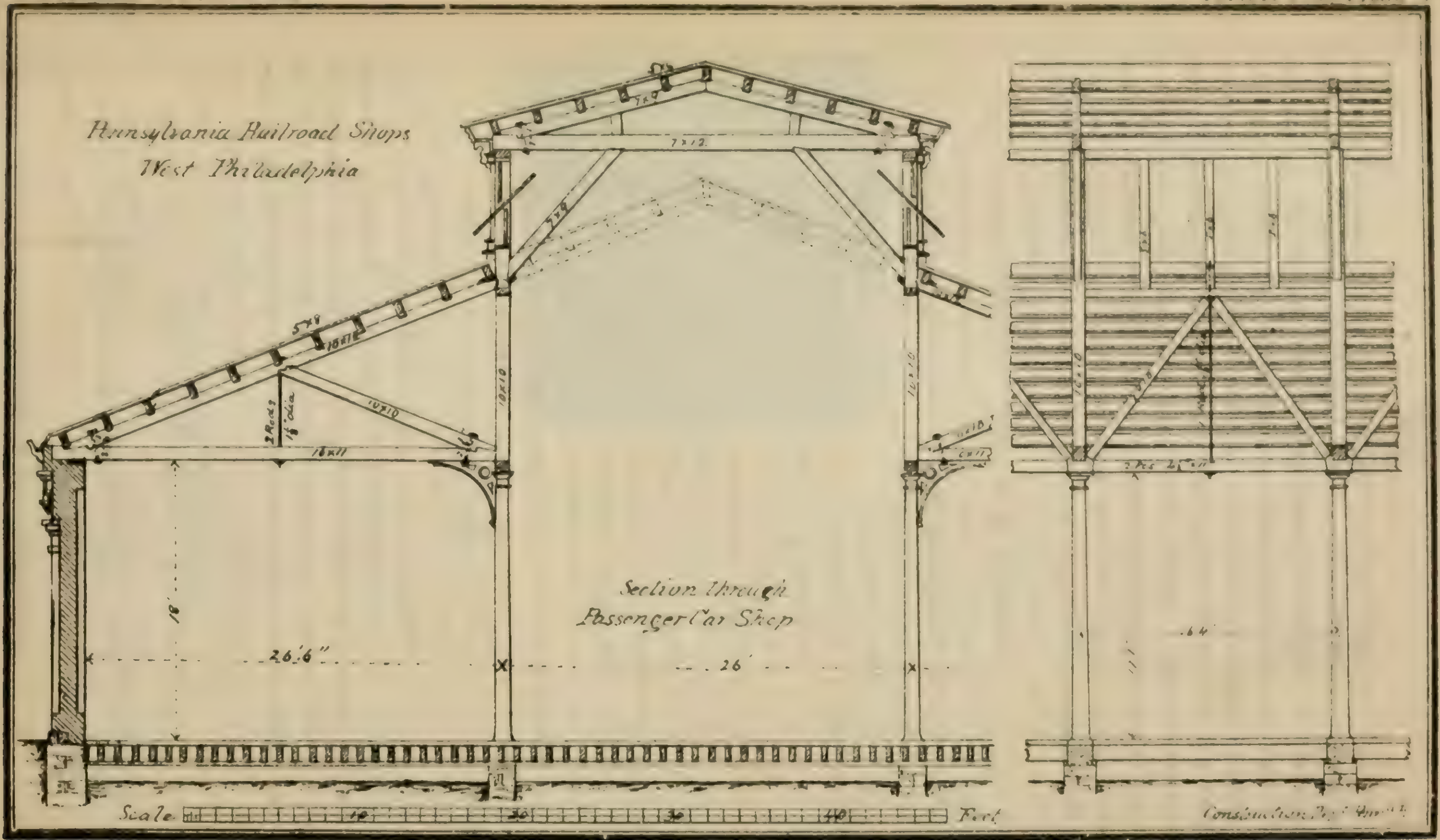
Wood Working Machine Shop.—This is designated No. 12 of Plate I, and covers an area of 132 feet 9 inches by 67 feet 5 inches, outside dimensions of brickwork. It is a building of one story, provided with a single span roof and ventilator, the construction being in every way similar to the other buildings. It has one track lengthwise through the building to facilitate transfer of lumber, and it contains the following wood-working machinery :

No. 1.	Boring Machine.	Made at W. P. Shops.
" 2.	Wood Lathe.	" " "
" 3.	Gig Saw.	" " "
" 4.	Moulding Machine.	Ball & Williams, makers.
" 5.	Wabble Circular Slit Saw.	Made at W. P. Shops.
" 6.	Cut-off Saw.	Ball & Williams, makers.
" 7.	Circular Slit Saw.	Made at W. P. Shops.
" 8.	Mortising Machine.	Lane & Boddley, makers.
" 9.	Daniel's Planer.	Ball & Williams, makers.
" 10.	Small Rip Saw.	Made at W. P. Shops.
" 11.	Surfacing Machine.	Gray & Wood's Pat., Ball & Williams, makers.
" 12.	Large Rip Saw.	Made at W. P. Shops.
" 13.	Large Cut-off Circular Saw.	Made at W. P. Shops.
" 14.	Grindstone.	
" 15.	"	
" 16.	Large Daniel's Planer.	Ball & Williams, makers.
" 17.	Tennon Machine.	" "
" 18.	Gaining Machine.	Made at W. P. Shops.

At No. 19 is a small tool room.

Paint Shop. This building, No. 13 of Plate I, is 132 feet 9 inches by 51 feet 1 inch outside dimensions, and is built in two stories. The first floor contains three tracks for cars, and has a clear height from floor to ceiling of 17 feet 5 inches. The second floor, which is supported by two rows of cast-iron columns in the first story, and has a clear height from floor to tie beam of roof of 16 feet 6 inches, is used for an upholstery shop, and also contains some machinery for the manufacture of car blinds, seats, &c. In details of construction, this building is similar to those previously described, and has a timber-hipped roof covered with slate, and no ventilator.

(To be continued.)


Pennsylvania Railroad Shops
West Philadelphia
Section through
Passenger Car Shop
7x9
7x12
5x8
10x12
2 Rods
1⅛" dia
10x10
16x11
18'
26'6"
26'
Scale
10
20
30
40
Feet

Chemistry, Physics, Technology, etc.

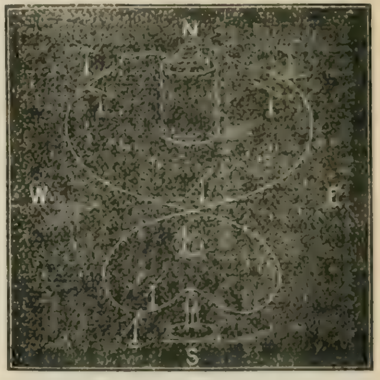
TERRESTRIAL MAGNETISM.

By Richard Owen, M.D. LL.D. of the Indiana State University.

Continuing the investigations alluded to in the October number for 1871 of this journal, I have reached some interesting conclusions. A portion of the results arrived at will be given in this communication, while others, requiring verification, are reserved for a future number.

For the sake of greater clearness, I will suppose the operator facing the north, and having before him one moderate-sized cell of Glove's Battery, the zinc arm turned to the left, that is the west.

Let one end of five or six feet of medium-sized wire be brought from the head screw of the platina, and extend from the operator's right (or the east), rising to make the top of a single circle; then, descending on the west to rise again on the east, pass to the left and be attached by that extremity of the wire to the zinc, thus (the needle being held in the hand):



The current now passes from the platina, around the copper circle, toward the zinc, and the effect on the needle is the same whether the first turn of the wire be next to the operator or the reverse, representing respectively the heliacal curve of the ecliptic, as in the winter of our northern hemisphere, or again as in our summer.

In order to observe the effect of this current on the needle, I have found it convenient to use a delicate compass, with agate centre, lifted from its case and made to oscillate on a sewing needle thrust through a portion of cork. When needed for experiments such as those hereafter detailed, the magnetic needle and sewing needle on the cork are placed in a shallow paper box which can be carried in the vest pocket.

It will be found that when the current of electricity (whether a vibratory or undulatory molecular motion, transmitted in vortical, heliacal or other curves, matters not for the present object) passes along the wire, the needle *outside* and near the copper circle will

stand in the natural position of all magnets which are fully suspended in the plane of the magnetic meridian, but *inside* the circle the poles will be reversed. When the needle is *above* the wire, on the experimenter's right, the north end of the needle will be deflected west; when it is *below* the wire the north end of the needle turns to the east. Just the reverse is the case when the needle is applied above or below the wire on the left, or west, or zinc end of the same.

All the above results accord, I believe, with the statements of the best writers on the subject from the days of Oersted to the present time, and they are here merely reviewed to make more apparent the conclusion to which we seem forced, namely, that if currents of electricity, in or about the earth's crust, are the cause of the magnetic needle (when free from all local disturbance) settling in the magnetic meridian with its north end nearly to the north, then those currents, if they encircle the earth from east to west, must be *beneath* the magnetic needle, not in the air above the needle. Consequently the vibrations must be comparatively deep in the earth's crust, being greater in power as we go deeper. This seems to be the conclusion arrived at by Mr. Robert Fox, after experimenting on electrical currents in metallic veins, as given p. 98, Part IV, of Electro-Magetism, in the "Library of Useful Knowledge."

Horizontal Induction.

There is, however, another mode of accounting for our horizontal needles settling north and south, even supposing those currents proved, and granting further that the magnetism exhibited in the earth may result from these currents: that other mode is by *induction*.

Every iron rail laid on a north and south railroad, so far as I have been able to examine, is a perfect magnet, the end stretching to the north attracting the south end of the needle for about half of its distance; while the end stretching south attracts the north end of the magnetic needle for about the other half of the entire length of the rail. If native lodestone or magnetic iron ore is rendered so by the earth's inductive power, just as these rails have been rendered magnetic by induction, then—if the first artificial magnets were made to acquire their directive tendency by drawing first one pole of the lodestone from centre to end of the steel bar or needle, afterwards the other lodestone pole being rubbed from centre to the opposite end (and successive artificial magnets have been manufactured from these first by drawing them from centre to each end at a given angle)—we are,

perhaps, justified in saying that almost all artificial magnets (whether as mariner's compass or other magnetic needles) have been made magnetic indirectly from the inductive action of the earth. Some, it is true, have been and can be made magnetic by hammering, or by electric shocks, &c.; others, also, by the violet rays of the sun's beam; but that would not invalidate the truth, as above stated, that almost all artificial magnets are made so by induction, not that form which acts feebly at a distance, but rather the more powerful by actual contact of other magnets, and indirectly of the earth.

As a transition from this mode of horizontal induction to another phase, vertical induction, I may mention that for some distance *near the middle* of each north and south rail of the so-called T railroad iron, instead of all parts of the T rail, whether tested by the needle above or below, attracting either the south or the north end of the needle, it will be found that the lower flange, whether tried on the east or west side, will attract the south end of the needle, while the upper flange attracts the north end of the needle.

This brings us to

Vertical Induction,

Or, perhaps, we might say induction separating the two magnetisms in a plane nearly at right angles to the plane formed by the supposed extension of the upper surface of a flat dipping needle.

All iron bodies, whether cast, hammered or rolled, which have for a longer or shorter period (sometimes a day or less sufficing) been fastened in a somewhat vertical position, or even left loose habitually in an upright position, become magnets, and most of them remain so permanently.

It is usually stated in works on this subject that pokers, shovels and the like standing for a time in a vertical position become magnetic. If the poker is of soft iron, I find the magnetism can be reversed in a moment by reversing the poker; but it is not so with many articles I have tried, even when made of sheet iron.

Thus, after testing several hundred articles of iron, that had been some time in permanent positions relatively to the earth, I found them invariably magnets, attracting the south end of the needle at the lower side, and the north end of the needle at the upper side. This polarity was not reversed when a sheet-iron vessel was turned bottom up for 12 hours. Thus the lower part of a cast-iron or sheet-iron stove, sheet iron bucket, tin pan (*i. e.* iron tinned), or iron fence, also the

lower straps bracing the trucks of a freight car, or the lower edges of the straps on the corners as well as the lower parts of all locks and hinges fastened on doors, attract the south end of the needle, while the upper parts of the same, the upper rail of the fence (when connected with the lower either by cast or wrought iron), or the upper part of a bucket or even of a shallow saucepan, will attract the north end of the needle.

The two iron straps with which the trucks of cars are braced, are united by rivets at each end, while above and below the axle they are more than a foot apart. Although the upper strap along most of its length attracts the north end of the needle, and the lower strap the south end, as just stated, yet where they come together, if the car has been standing or running some time in a given direction, the junction and rivet next the north end of the railroad will attract the south end of the needle, while the junction and rivet pointing to the south end of the road will attract the north end of the needle.

The old cast trucks or car wheels (united by their axles) which have been for some time in one position, near the machine shops, standing on north or south rails, are found also to exhibit the effects of both vertical and horizontal induction, for every wheel at its upper part of the rim attracts the north end of the needle, while at its bottom it attracts the south end; again half way from bottom to top on the part of the rim facing the north it attracts the south end of the needle, while on the rim facing the south we find magnetism attracting the north end of the needle. I use the term vertical induction, because it seems evident that all bodies occupying a nearly vertical position have the opposite magnetism of that evinced by our northern hemisphere, attracted nearest to our part of the earth's crust, while the magnetism, similar to that of our earth here, is repelled to the upper part of the iron article, whatever it may be and of whatever length. The division between the two magnetisms seems to vary; but in a nearly cubical sheet-iron vessel used for chemical purposes in the laboratory of the Indiana State University, I marked with chalk the turning point of the needle on the four upright sides, and connected these by lines. These lines were found to occupy a plane nearly at right angles to the plane of the upper surface of the dipping needle at this place.

Another result, which might have been expected from the analogy between the vessels thus found magnetic and any artificial magnet, deserves a brief notice.

A new French coffee-pot, capable of being separated a little above its middle so that the part containing the strainer becomes a distinct upper vessel, was found when entire to attract the south end of the needle when presented near the bottom of the vessel, and the north end, when presented anywhere from below the middle to the summit. When, however, the coffee-pot was separated, so as to make two vessels, *each* had its distinctive polarity, just as in breaking a magnet in two and obtaining two magnets.

It seems quite possible that considerable influence may be produced in various ways by this disturbance of the magnetic equilibrium, existing, as it appeared to do, in all the vessels ordinarily used for culinary and other domestic purposes; but for the present it is perhaps sufficient to call attention to this effect of induction operating so very extensively, the verification of which can be so readily and interestingly accomplished by any one having a delicate magnetic needle.

As a horizontal needle weighted on its south end for the northern hemisphere, and on the north end for the southern hemisphere, in order to overcome the dip, will continue to point north and south in either nemisphere, so a north and south rail, taken up after lying some time on the earth in either hemisphere and swung freely, would set itself, as it lay in the ground, north and south. But in the case of vertical induction, as the dipping needle is horizontal near the equator (say at St. Thomas' Island, close to west coast of Africa) while at the magnetic north pole the *north* end would turn down and point to the centre of the earth, and at the magnetic south pole the dipping needle would point with its *south* end to the centre of the earth, the phenomena of vertical induction would seem to be necessarily reversed in these two hemispheres, except near the equator, where vertical induc duction would probably be lost or merged in horizontal induction.

It would be highly interesting if some scientific men would examine, at the Cape of Good Hope, or in Australia, or in South America, and give us the results of their examinations. Also if some, stationed near the magnetic equator, would apply the tests above and give results.

To prevent misapprehension, it may be proper to remark that, in using the term magnetism as applied to the power communicated to iron vessels by the earth's induction, it is not meant to imply that all these vessels, &c., can be made to exhibit the power of attracting iron filings (although some pointed articles do so), but rather that they all

exhibit polarity, whereas iron in which, from its constant change of position no such induction has taken place, would attract either end of the needle with equal readiness.

I may also add that the converse of separating a tinned vessel, as a coffee-pot, into two parts and obtaining two magnets, holds good; for if we take two tin cups or two cans of equal size, and having each polarity, and place one on the other, we shall have the lower vessel attract the south pole of the needle, the upper vessel the north pole of the needle, as if they constituted but one magnet.

Magnetic Springs.

As the waters (in which steel instruments or tools, such as axes, &c., when left some hours became magnetic) have latterly been exciting interest in a medical point of view, in consequence of their reported therapeutic power in various diseases, I concluded to make some experiments, endeavoring to ascertain the manner in which the waters become magnetic.

Pouring half a gallon of rain water into a small tub, I placed two steel magnets (half-inch bars a foot long) parallel to each other in the plane of the magnetic meridian, in the water six inches apart and having opposite poles facing each other. I then dropped a tenpenny nail between them in an east and west line, near the north side of the tub. After five hours the tenpenny nail, when taken out, lifted a tack of the size known as 8 oz. tacks. Taking the magnets out, I then dropped another tenpenny nail into the water, which had thus been impregnated with magnetism; and in twelve hours found this nail would, when taken out and dried, lift an 8 oz. tack also.

Time has not permitted, as yet, any variation in this latter experiment, but should the subsequent results either confirm or contradict those obtained above, I shall communicate them.

MONTHLY RAINFALL AT SAN FRANCISCO.

By Pliny Earle Chase, Professor of Physics in Haverford College.

Mr. Thomas Tennent has published a chart, compiled from his own observations, of the monthly amounts of rain in San Francisco for twenty-two years, from July 1st, 1849, to July 1st, 1871. I have grouped the amounts in seven short periods, and computed the normal ordinates (N) for the several curves, which are given, together with the observed amounts (R), in the following table:

SAN FRANCISCO RAINFALL.

	1849—52		1852—55		1855—58		1858—62	
	R.	N.	R.	N.	R.	N.	R.	N.
July	......	3	......	3	·02	2	·26	6
August	......	9	·05	6	·05	3	·18	4
September	1·03	41	·61	23	·07	16	·05	19
October	3·35	111	3·33	65	1.38	57	3·70	64
November	12·03	196	7 93	116	6 47	136	12·65	142
December	14.35	228	16·33	176	13·65	219	23·41	220
January	9·64	191	11·47	103	16·21	249	29 75	248
February	2·45	155	14 23	194	10 92	217	19·17	208
March	13·15	136	13 01	185	8 77	156	13 29	140
April	1·95	90	13·49	142	4·49	92	4 65	83
May	·99	34	2 28	74	1·12	40	6·15	46
June	......	8	.08	21	·20	12	·22	21

	1862—65		1865—68		1868—71		1849—71	
	R.	N.	R.	N.	R.	N.	R.	N.
July	......	5	......	2	......	1	·28	3
August	·21	3	......	1	......	3	·49	4
September	·04	20	·39	11	·15	12	2·34	20
October	·53	84	·46	58	1·44	44	14·19	67
November	9·38	187	10·95	155	2·80	115	62·21	149
December	13·06	252	26·43	249	12 63	206	119·26	221
January	15·60	229	25·54	267	13·31	257	116·52	235
February	4·53	161	15·45	210	12·44	235	79·19	200
March	4·32	113	10·92	135	6·43	171	69·89	148
April	4·13	81	4·79	73	5·65	101	39·14	94
May	1·64	48	1·49	31	·49	44	14·16	45
June	......	17	·27	9	·02	11	·79	15

There is so much similarity between the different curves, their general character is so much like that of the Lisbon curves, and they accord so nearly with the annual temperature curve, that they may reasonably be regarded as typical, and the daily records may probably furnish materials for more minute and detailed profitable investigation.

Among the deductions in my paper on the "Tidal rainfall of Philadelphia," (*Proc. Amer. Phil. Soc. x.*, 530), were the two following:

1. "The tidal rainfall, like the ocean tides, is affected by 'establishments,' which depend upon ocean currents, mountain ranges, prevailing winds and other climatic influences.

2. "It is also, like the ocean tides, more marked in low, than in high latitudes."

These inferences are strikingly corroborated by the Lisbon records, and I look confidently for equally striking additional confirmation from observations on our Pacific coast. Moreover, I think that my previous discussions, combined with generalizations from the meteorological reports of the Signal Service Bureau, and with well known tidal laws, are sufficient to justify the following predictions:

1. The tidal rainfall will generally be found more strongly marked on the western shores of the several continents, than in the same latitudes on the eastern shores.

2. When the rainfalls at any given station are grouped both in accordance with the age of the moon and the direction of the wind which brings the rain, opposition of winds will be found to affect the tidal curves similarly to opposition of direction from large bodies of water.

3. A certain degree of apparent opposition will be found to exist between the lunar influence upon the upper and lower cloud strata, dependent upon the normal difference of position in the tidal crests of deep and shallow fluid envelopes.

4. The satisfactory determination of the lunar influence upon atmospheric currents is practicable, although vastly more laborious than the determination of the laws of tidal rainfall. Glaisher has already shown that there is such an influence, but there have been no published discussions of its amount or general character.

THE RUMFORD MEDALS.

At the last annual meeting of the American Academy of Arts and Sciences, held in Boston, May 30th, 1871, the Rumford premium was awarded to Mr. Joseph Harrison, Jr., of Philadelphia, "*for his method of constructing steam boilers, by which great safety has been secured.*" According to the directions of Count Rumford this premium was given in two medals—one of gold and one of silver—together of the intrinsic value of three hundred dollars, and at the last monthly meeting of the Academy, a formal presentation of the medals was made.

The medals presented to Mr. Harrison are alike except in the kind of metal of which they are made. On the obverse is a bass-relief portrait of the count, surrounded by his name and the dates of his birth and death (1755 and 1814). On the reverse is the following inscription :—

"*Rumford Medal for discoveries in Light or Heat. Awarded by the American Academy of Arts and Sciences, to Joseph Harrison, Jr., for his method of constructing steam boilers, by which great safety has been secured. May* 30, 1871."

The grounds on which the medal has been awarded to Mr. Harrison are fully set forth in the following statement of the Rumford commit-

tee of the Academy, which was adopted at a full meeting of the committee held December 23, 1871, and was read to the Academy, Tuesday evening, by the chairman of the committee, Professor Josiah P. Cooke, Jr.:

The "Harrison boiler" consists of a number of hollow cast-iron spheres, about eight inches in external diameter and one quarter of an inch thick. These spheres are cast in groups of two or four, the spheres of each group being arranged in straight lines and connected with each other by curved necks about three and one quarter inches in diameter. Moreover, each sphere has two half necks which make openings at right angles to the necks previously mentioned. The open necks are rabbeted so that any number of the groups of spheres (units as they are called) may be united to each other, and the system thus built up is held together by wrought-iron tie-bolts, which pass through each line of spheres in the direction of the half or jointed necks, connecting at each end with caps that close the external orifices of the end spheres on each line. The castings are made with such uniformity, and the necks turned so as to fit each other with such accuracy, that when rabbeted ends are adjusted and drawn together by the screw and nut at the end of each bolt, a perfectly steam and water-tight joint is secured without the intervention of cement or packing. A system of spheres thus united, six wide and twelve or thirteen long, forms what is called a section, and a boiler consists of several of these sections all discharging steam into the same pipe. In setting the boiler the sections are placed on edge, side by side, so that the lines of bolts make an angle of about forty degrees with the furnace grate.

The security of the "Harrison boiler" depends upon the following features in its mode of construction. In the first place the spherical form adopted for the units of the boiler greatly economizes the tensile strength of the iron, and it has been estimated that with a metal having a tensile strength of three and one-half tons to the square inch, the bursting strength of the units would be nearly three-fourths of a ton per square inch. The strength of a boiler consisting of such units will of course be no greater than that of the weakest sphere of the structure; but as all the sections are tested at the manufactory by hydrostatic pressure as high as three hundred pounds to the square inch, a defective unit is discovered before the boiler is delivered to purchasers.

It is not maintained, however, that the units of the "Harrison

boiler" cannot be burst under excessive pressure, for, as experience has shown, it is impossible to make a vessel—at least one of any practical value as a steam generator—which cannot be burst. It is merely a question how high a pressure it can stand before yielding. But the evidence before the Rumford committee has sustained the opinion that in case of such an accident to the "Harrison boiler" a violent, destructive explosion is almost impossible; and this brings us to the consideration of the second feature on which the security of this boiler depends.

In an ordinary plate-iron boiler the yielding at any point almost inevitably involves the rending and complete destruction of the whole structure. A tear started at a defective rivet or on a line of corrosion will instantly lay open the whole vessel, when the expanding steam scatters the contents in all directions and hurls the fragments with a force that no ordinary construction of buildings or ships can withstand. The recent experiments of Mr. Stevens, of Hoboken, as described in a report to the Secretary of the Navy by three of the chief engineers in the naval service, show very conclusively that this tearing apart of the boiler plates under pressure is the simple cause of the destructive explosions of plate-iron boilers, and, to use the words of the report, "that in accounting for either the fact of an explosion or for its destructive effects there is no necessity for hypotheses of low water, enormous pressure, instantaneous generation of immense quantities of steam, superheated steam, the formation of hypothetical gases, the development of electricity, etc. The most frightful catastrophe can be produced by simply gradually accumulating the pressure of the saturated steam to a strain at which the strength of the boiler yields, nor need that pressure be much above what is ordinarily employed with boilers of this type." In one experiment the boiler exploded with most destructive violence in less than a quarter of an hour after the pressure had passed the inspector's limit.

Such a sudden tearing open of the whole vessel has never taken place and does not seem to be possible with the "Harrison boiler." Under an excessive pressure, the weakest unit in the system may yield and injury may be caused by the sudden discharge of water or of steam, but the injury to the boiler must be, to a great extent, local, probably extending only to the breaking of a single unit, and involving at the most a rapid but still regulated emptying of its contents. The parts being wholly independent, there is no tendency in a rupture to extend from one unit to its neighbors, and, moreover, as a general

rule, long before the bursting point is reached, a third feature of the boiler comes into play which, perhaps, more than either of the two others, protects it from destructive explosions. The units of the boiler not being cemented together, the least yielding of the bolts opens every joint and makes each of them a safety valve. That this is the normal action of the boiler under excessive pressure has been abundantly established, not only by the experiments made by Mr. Harrison before a committee of the Franklin Institute, but also by the experience of a member of our own committee.

The Rumford committee were satisfied by the evidence herein stated that the "Harrison boiler" is not liable to those violent destructive explosions referred to above, and to which the ordinary plate-iron boilers, however carefully or strongly made, must be always more or less exposed. Considering further the economical advantages to be gained from high pressure steam, and the paramount importance of such security as Mr. Harrison has attained in the use of this powerful agent, they felt themselves justified in making the recommendation on which the Academy acted in awarding to him the Rumford medal. It must be noticed, however, that the award has been made for a "mode of constructing steam boilers by which *greater safety is secured*," and that the safety of the boiler is the only point on which the committee based their recommendation. They did not feel themselves called upon to weigh carefully the relative merits of the "Harrison boiler" when compared in *other* respects with the many forms of steam boilers now in the market. They considered that its already extended and rapidly increasing use was sufficient evidence that the "Harrison boiler" was an efficient and economical steam generator. More than this they did not require to be proved; for whatever might be the defects of the boiler—and some doubtless there are—the committee considered that Mr. Harrison had made an important advance in the application of steam by demonstrating experimentally the principles on which a safe steam boiler can be made, and working them out to a practical result. These principles being established, we may hope that the alleged defects in the present construction may be hereafter remedied.

It remains only to be considered how far the principles or features of construction to which we have referred are original with Mr. Harrison. At least twenty-five years ago Dr. Ernst Alban, a distinguished German engineer, clearly recognizing the impossibility of securing safety in a steam boiler by strength of materials alone, ad-

vanced the important opinion that the only sure method of avoiding danger is "so to construct the boiler that its explosions may not be dangerous," and in a valuable work, originally published in Germany, but of which an English translation, published in 1848, was alone before the committee, a mode of constructing steam boilers is described, in which this principle is skilfully applied. Mr. Harrison has adopted the principle of Dr. Alban, and in a pamphlet on the steam boiler published in Philadelphia in 1867 he prints the opinion of Dr. Alban, quoted above, at the head of his essay, but his method of embodying this principle is as dissimilar as possible. Moreover, he has carried out the principle more fully than Alban himself. The German boiler, like the American, is made in sections, so that the bursting of one would bring no destructive consequences upon the general body of the boiler; but it is merely a modification of the well-known tubular boiler, and does not combine the advantages which Harrison obtains from the spherical form of his units and the mode by which they are bolted together without rivets or cement.

But the merit of Mr. Harrison and his claim to the Rumford medal consists fully as much in the skill with which he has overcome the difficulties in the details of the construction of his boiler as in the ingenuity of the original design. The boiler is not an ideal conception, but an accomplished result, of which the industry of the country is enjoying the benefit. By Mr. Harrison's labors, high pressure steam has been brought more under control, and human life has been rendered more secure. The Rumford committee believe that in awarding the Rumford medal to Mr. Harrison, the Academy are not only faithfully carrying out the expressed wishes of their benefactor, but also that Mr. Harrison's invention is one which Count Rumford would have especially delighted to honor.

Mr. Harrison, in consequence of illness, not being able to be present at the meeting, the medals were delivered, at his request, to Mr. John A. Coleman, who read to the Academy the following letter of acknowledgment:

To the President and Members of the American Academy of Arts and Sciences:

Mr. President and Gentlemen:—In receiving the Rumford medals awarded to me in so flattering a manner by the American Academy of Arts and Sciences, I fear I cannot express in suitable terms my appreciation of this most distinguished honor. I can therefore only

say that I do esteem this compliment very highly indeed. To my mind, there is nothing within the limits of science at this present time that is of more importance than the "application of heat" to the safe generation of steam, and to have won a recognized distinction in such a field, and to have been deemed worthy of the reward that I have now received, fully repays me for many years of anxious and often discouraging effort. In what I have done I claim but little merit beyond calling attention for the last twelve years to the great importance of the subject, and in having in some degree demonstrated the fact that a steam-generator can be made secure from destructive explosion. I think that this idea has now taken such firm hold upon the public mind, both in this country and in Europe, that it may be fairly inferred that in the future the use of steam under pressure will not be attended with the disastrous results that are recorded in the past. In regretting my inability to be present at your meeting on January the 9th, so as to receive the medals in person, I most sincerely thank you, Mr. President and members of the American Academy of Arts and Sciences, for this very high mark of approval.

JOSEPH HARRISON, JR.

Philadelphia, January 6th, 1871.

The medals presented to Mr. Harrison are the sixth award of the Rumford premium made by the American Academy. The other awards have been made as follows:

In 1839, to Dr. Robert Hare, of Philadelphia, for his invention of the compound blow-pipe, and his improvements in galvanic apparatus.

In 1862, to Mr. John B. Ericsson, of New York, for his caloric engine.

In 1865, to Professor Daniel Treadwell, of Cambridge, for his improvements in the management of heat.

In 1867, to Mr. Alvan Clark, of Cambridge, for his improvements in the manufacture of refracting telescopes, as exhibited in his method of local correction.

In 1870, to Mr. George H. Corliss, of Providence, for improvements in the steam engine.

It was directed by Count Rumford that the premium should be given "to the author of the most important discovery or useful improvement, which shall be made and published by printing or in any way made known to the publick, in any part of the Continent of America or in any of the American Islands, during the preceding two years, on Heat or on Light; the preference always being given to

such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind." In Count Rumford's original letter of donation, dated London, July 12th, 1796, beside the above, several other directions are given, with some of which the Academy found it impracticable, or at least very inexpedient to comply literally, and for this reason the premium was not awarded during a long series of years. The Academy is now acting under a decree of the Supreme Judicial Court of the Commonwealth of Massachusetts, especially authorized by an Act of the Legislature of the State, approved by the Governor March 16th, 1831. This decree enables them to award the premium at any annual meeting, and relieves them from the necessity of limiting its application to discoveries or improvements made during the two years immediately preceding the award. All interested in the subject will find a full statement of the facts in the Life of Count Rumford, by the Rev. George E. Ellis, D. D., of Boston, recently published for the Academy (in connection with an edition of Rumford's complete works) by Claxton, Remsen & Haffelfinger, 319 and 321 Market St., Philadelphia.

A committee, consisting of seven fellows, called the Rumford Committee, is annually appointed by the Academy, and it is their duty to investigate all claims for the Rumford premium. The premium is awarded only on the recommendation of this Committee, and at the annual meeting of the Academy held on the fourth Tuesday in May. The Rumford fund would enable the Academy to give the medals every year, but the premium can be awarded only for a new discovery in light or heat, or for a substantial improvement in the application of these agents to the arts of life, whose usefulness has been tested by experience.

All communications on the subject of the Rumford premium should be addressed to the Chairman of the Rumford Committee, American Academy of Arts and Sciences, Boston, Mass.

LECTURES ON VENTILATION.

Delivered before the Franklin Institute.

By L. W. Leeds, Esq.

(Continued from Vol. LIV, page 120.)

I have hung on the sides of the room—one on the right and the other on the left—the two lists of tables of the analysis of the air I copied from a report to Congress on the ventilation of the capitol,

made by Professor Henry, Thomas U. Walter, and Dr. Wetherill. (The same tables used last year—see page 17.)

The one on your right hand shows the amount of carbonic acid in the open air; and the one on the left, the amount found in buildings.

By an examination of these you will readily see that all external air, such as the sheep, and calves, and colts have to breathe, is uniformly very pure, while that in houses, such as we and our children have to breathe, is very different.

You see, here, in our scientific lecture-rooms, school-houses, bed-rooms, we have 50, 60, and even 72 parts of carbonic acid in 10,000.

It is that excess of carbonic acid—over 5 parts in 10,000—that represents the foul poisonous condition of the air of our houses, which is killing so many of the people of this country.

I consider these tables valuable, because they are nearly all the analyses of air that have ever been made. Comparatively speaking, we do not know anything about that subject as we ought to know.

Let me ask you if it is not passing strange that a great and intelligent nation, like the United States, should so utterly neglect this important subject? A nation that can raise such vast armies, and can raise millions, hundreds and thousands of millions of dollars for destroying each other in time of war, yet scarcely one dollar for analyzing the air and endeavoring to control it and prevent the destruction of human life by that fearful poison—foul air—that killed more persons in the United States last year (a year of profound peace) than were killed on the Union side by sickness, and by the enemy, during the entire late war.

If there is a case of poisoning by arsenic or strychnine, the whole city is thrown into a state of feverish excitement, and if not suspected until after the body is buried, it is exhumed and the most skilful chemists work faithfully over it to ascertain, if possible, some trace of the poison: and yet some 3,000 children were poisoned to death in this city by foul air last year, and can you produce one solitary record of the analysis of the air of the room in which they were thus killed?

Is there one of your medical colleges, the boast and pride of this city, that teaches its students, by careful analysis of the air, readily to detect and how to remedy those impurities which physicians must constantly meet with in the sick-room? Let us hope that the day is not far distant when the people will be aroused from their guilty apathy and indifference upon this subject.

We now propose examining the ventilation and heating, as it is applied in various public and private buildings with which you are familiar.

It is not a pleasant task to examine and find fault with the new and splendid buildings that have just been completed, at such great cost, and which are looked upon by their owners and most casual observers as models of beauty and perfection. But, are not these buildings the true index of the general public information upon these subjects? And is it not, therefore, best for all of us that we should give them the most critical examination, and if they are merely showy tombs, as it were, and entirely devoid of the proper supply of that life-giving element, *pure air*, to acknowledge the truth promptly and then set ourselves to work energetically to endeavor to learn the best way of improving these, and avoiding such mistakes in all new ones?

There is no building in the world, perhaps, upon which there is such a decided diversity of opinion among scientific men as to the perfection of its ventilation as there is respecting the Capitol at Washington. I have devoted much time for many years past to studying its peculiarities, and I think if the mere question of a constant supply of air to the main rooms was the only one, it can readily be proven to be well ventilated, and yet it would be very difficult to get any considerable number of the owners who are obliged to occupy the building for a large portion of the year, to consent to any such statement.

The universal dissatisfaction is probably owing as much to the quality of the air supplied, and the manner of heating it, as to the quantity.

I consider this a good example of the ill effects of that detestable system that we as a nation have fallen into, of attempting to warm our buildings by over-heating, and thus ruining all the air used for breathing.

The total absence of any direct radiation is a marked feature, for there is not only the entire absence of any artificial radiation from exposed steam-pipes, etc., but there is the additional absence of radiation from the great natural source of all heat, the sun.

The direct rays of the sun I believe to be not only the most magnificent warming power, but also the greatest disinfecting and purifying power we have, and they are of the utmost value for the vigorous development and exercise of all our physical and mental faculties.

It appears to have been originally designed to exclude the main

halls as much as possible from all external influences, and to have all the currents, the heating and the lighting, under perfect artificial control.

But if the whole nation could be taught the valuable lesson of the great folly of attempting to produce artificial light, artificial heat, and artificially mixed air, that shall be equal to that which our Creator has provided for us, that knowledge would be cheaply bought at the great price paid for these buildings.

I tried a large number of experiments during the winter of '67 and '68 to ascertain the direction of the prevailing currents through the Hall of Representatives and the relative temperatures in all parts of the building. I was rather surprised to find them so distinct and well defined, and also that they were so free from disturbance by the changes in the direction and force of the external currents.

The heat all entering the hall, or passing under it on the west side, gave an additional temperature of 4 or 5°, which was sufficient to cause an ascending current at that end, which produced a corresponding descending current at the other end. A very striking feature was the effect of the exposed copper roof in cooling the foul air and causing it to fall back again on to the floor of the house.

It will be seen by reference to these figures (see diagram) that when the thermometer indicated 61° near the floor, the thermometer over the glass ceiling indicated 56°, while those around the sides were only 40° and 38°. I found a strong descending current of this cooled foul air descending on three sides, sweeping over the galleries, and tumbling down on to the floor.

This was bad enough through the day, when the air was only polluted by human beings, water closets, steam-engines, restaurants, etc.; but at night, when the products of many hundred gas-lights were added to it, it became almost insufferable. I noticed that in four minutes after the gas was turned on for lighting in the loft, we perceived it on the floor, and in fifteen minutes it became very oppressive.

I wish to call your attention particularly to this system of ventilating directly into a loft; I find it very often in churches, and in many other buildings where the openings are made directly into this space under the roof, and frequently in schools a whole system of flues will empty into such a place. Sometimes there will be a small blind window in the gables, and sometimes a small ventilator on the roof, but not connected with the ventilating flues.

This is all wrong—a very deceptive, pernicious system. If there

is any circulation, there is almost sure to be a descending current of cold foul air where you do not want it, or very commonly there will be but little or no current at all—and such ventilators will be mere deceptions, much like that handsome frescoed ventilator on the solid wall of the Washington church.

Much care should be taken to prevent the escaping foul air from being cooled down below the temperature of the room so as to cause it to return; the exit pipes should be continued of one uniform size until the foul air is delivered entirely out of the building.

To return to the House of Representatives:—Now, when you add to this revolving and continued resoiling treatment of the air after it gets into the hall, the source from whence it comes, I think we have excuse enough for the complaints of these country members who have been accustomed to tolerably pure air.

Some of the members, who have been lawyers, and therefore obliged to spend much of their time in our court-rooms and city offices, and newspaper editors, seem to be very much at home in such an atmosphere—they may enjoy it.

The fresh ! air is taken in through the basement into the cellar, and there forced up by fans through an immense stack of dirty, rusty iron pipes, coated by many years' accumulation of rust, particles of decaying animal and vegetable matter, roasted up afresh every day; from thence it is driven through a labyrinth of uncleaned horizontal air ducts, filled with the moulding and decaying dirt that has collected for years, and finally driven through the uncleaned spittoons (originally intended for registers) arranged all over the floor of the house, issuing into the room at a temperature of from 100° to 120°—a warm, debilitating, filthy, disgusting mass for the members to breathe.

And yet some of the committees, in making very elaborate examinations and reports to Congress, fail to discover any very excessive amount of carbonic acid, and by counting the number of revolutions of the great fan, and calculating how much fresh ! air ought to be thrown in at each turn thereof, suppose there must necessarily be an abundance of air, such as it is, sent into the building somewhere; consequently they declare it to be the best ventilated building in the world.

But these reports have not generally given very accurate information as to the effect upon the members of breathing air nearly the temperature of the body while being surrounded by cold walls and a cold roof, nor how much of the cooked grease from the engine, or the smells from the water closets, or gas from the illuminating loft, etc., is mixed up with the air.

(To be continued.)

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXIII.] APRIL, 1872. No. 4

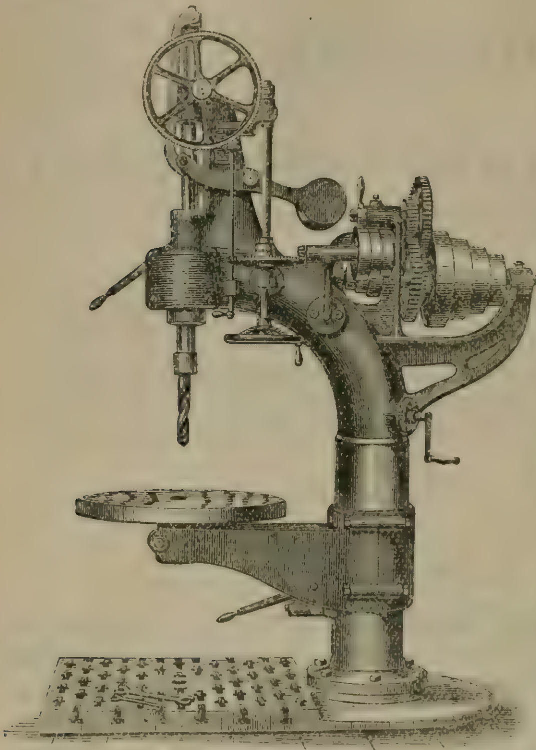
EDITORIAL.

ITEMS AND NOVELTIES.

The Upright Drilling Machine we illustrate, is from the Industrial Works of Wm. B. Bement & Sons, Philadelphia, and possesses a number of features worthy of notice. The following description will present the chief points of interest :

The machine is driven by cone with four changes for a three inch belt communicating with spindle by bevel gears. When increased power is desired, back gears are used, which are thrown into gear by an eccentric stud and also by a clutch pin, the head of which is visible at back end of outer cone bearing. The spindle is balanced, and is so arranged that it can be drawn through the whole distance of its traverse by one movement of a hand lever attached to balance lever stud. This is very convenient, as it facilitates the withdrawing of the drill and the clearing out of chips from a deep hole, and is also useful in starting a hole, as the hand lever is used altogether until the drill is ascertained to be cutting centrally. The machine has a self-feed, with three changes, also hand-feed. The self-feed is disconnected from the hand-feed by means of a clutch pin at the lower end of worm rod (under the hand wheel and not shown). When it is desired to use the hand lever for quick movement of spindle, the worm is disengaged

from the worm wheel by means of an upright rod with eccentric pin at upper end.



The table swings on its centre and around the column, by which means a piece can be drilled on any part of its surface without re-setting. In the lower part of the bracket holding the table, is a pin, which by being pushed into the heavy brass nut which supports the bracket, holds the table in a central position, and thus affords a bearing for a boring bar. The base plate can also be used for drilling or boring by swinging the table out of the way. The table is raised or lowered by screw and pinions inside the column. The drill is held in the spindle by friction, and is prevented from turning by a slot made to receive the upper end of shank.

The firm build four sizes of these machines, having the following capacities, viz: Distance from edge of column to centre of drill, 16 inches, 20 inches, 25 inches, and 30 inches.

A Magnetic Lock.—A lock of this description has been adopted, we are informed, in some of the English collieries, with a view to prevent miners and others employed in the collieries from opening their lamps with forged keys and other implements.

The lamps are self-locking, and cannot be opened save by aid of a powerful magnet, in the possession of the lamp-keeper. The invention is said to be applicable to any form of lamp, and to cost about a shilling. Any device by which the miner's lamp could be closed en-

tirely, except to some authorized person, would be a source of great safety.

A Navigable Balloon.—To M. Dupuy de Lome belongs the merit of having demonstrated by actual experiment the possibility of controlling (though but to a limited extent) the speed and direction of an air-ship.

The experiment was conducted with a balloon of peculiar construction (a large one with a small one inside to insure stability of form to the first), of an elongated shape, to offer least resistance to its motion.

The motive power, by which the question of increasing the speed of the vessel above that of the stratum of air in which it floated was successfully determined, consisted of a screw, operated by four men; while the directional impulse was given by a rudder formed of a triangular sail placed beneath the balloon. The height of this sail is 16 ft. 4 in. and its surface 161 sq. ft. Its position is controlled by two ropes, extending forward to the seat of the steerer.

The following comments, from Mr. John Wise, the librarian of the Institute, and perhaps the most experienced and accomplished of living aeronauts, may prove of interest in this connection:

"Dr. Solomon Andrews, of Perth Amboy, built an air-ship, which so far as the device to secure the stability of the float was concerned, was identical with that of De Lome's, about 15 years ago, but his motive power was intended to have been derived from gravitation. He had a rigid rim around the outer edge of the float, and the car with its weight was fixed to the balloon in such a manner that, by placing the weight at one end of it, it would be borne by the rigid rim, but when placed at the opposite end the weight would be borne by the elastic float, compressing the gas therein and causing the balloon to gravitate. By this alternation of compression and dilatation he would acquire momentum, and thus move forward in zigzag undulations, in the same way as the thistle-bird flies.

"But Andrews, like Dupuy de Lome, discovered by experience that when his vessel was afloat the wind would carry it along upon its current with very little deviation form its own course. If De Lome progressed 6 miles per hour faster than the breeze in which he floated, and was able to deviate 12 deg. to the right or left of his current line, he may flatter himself that he has taken all out of the navigable balloon that there is in it, as a machine dependent upon rudder and propeller. We may safely say this much for his air-ship, that it is

the best contrived piece of aerial machinery of the balloon kind, fixed with propelling apparatus, that has thus far been devised.

"We claim, however, much more for the balloon than all that has been done by attempting to use it as a steam-ship is used, *i. e.*, with wheels and rudder. As a drifting machine, with compensating appliances to regulate its altitude without the loss of gas or ballast, we can use it to sail to any part of the world. The balance-rope, as suggested by Baldwin and first used by Greene, is all the machinery necessary to enable us to go whither we desire. The trade winds give us the line of direction, and by a little barometrical experience we may soon learn to track the highways of the atmosphere, in order to travel to our points of destination with as much accuracy as does the mariner.

"Practical aeronauts have long ago learned that the balloon must find its use in another direction than that of imitating the water craft."

The Gardner Fire-Extinguisher.—The machine of which an exterior and sectional view are appended, is identical in principle of operation to the numerous extinguishers already known to the readers of the Journal, but differs in several details of construction involving the questions of convenience and efficiency.

Fig. 1.

The main feature of the apparatus, which was described at a recent meeting of the Institute, resides in the fact that the acid and carbonate are kept in separate chambers, and that the gas is generated in a third chamber, from which it is delivered.

By keeping the ingredients in separate reservoirs until it is desired to utilize them, it is claimed, and we believe justly, that there will be less liability of an accident occurring to render the charge worthless; while by generating the gas in a special chamber, the stream is retained un-

der perfect control, and can be checked when one-fourth, one-half, or any portion of the charge is expended, the remainder serving for a future occasion. This is, without doubt, a valuable feature, in point of cleanliness, economy, and wear upon the apparatus.

Fig. 2.

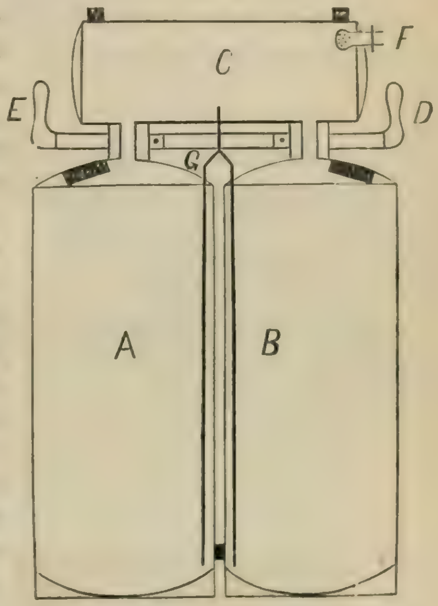


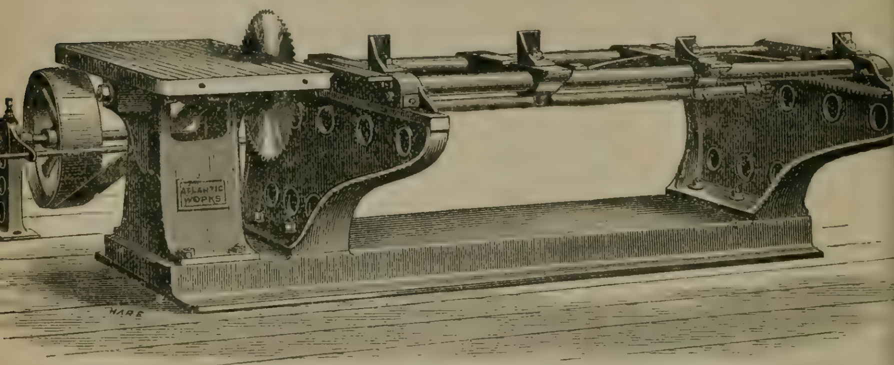
Fig. 1 gives an exterior view of the apparatus in position for use. In fig. 2 the interior arrangement is visible. A and B are respectively the chambers for storing acid and carbonate. These chambers connect with a horizontal reservoir, C, the passages thereto being controlled by turning either of the handles, D or E. F is the delivery pipe for the gas, while G is a branching pipe, open above and below, by which the pressure in the gas chamber is transmitted to the liquids in A and B, and their equable flow into C is assured. The charge of acid and carbonate is made in their equivalent proportions, so that when consumed neither shall be in excess.

The reservoirs are built of lead-lined copper, and the cocks are made of lead-bronze, to resist chemical action. When not in use, the apparatus is, as shown in fig. 2, set away bottom uppermost, by which the liquids are kept from contact with the cocks and mechanical arrangements.

The apparatus seems to us to be well worthy of commendation, inasmuch as it combines all the good qualities of other machines with the special advantages of greater convenience of form, security of the cocks from the action of the materials employed, and of the perfect control of the stream of gas.

While believing that some misapprehension exists as to the true cause of the efficiency of this and similar gas-generating machines (a question which is now being tested by the Institute Committee on Science and the Arts), we can endorse this form, as the most practical of any yet made public.

Carriage Cutting-off and Squaring Machine.—The accompanying figure shows a perspective elevation of a machine of this kind, bnilt for the New Haven and Northampton Railway Company by Richards, London & Kelley, of this city. The arrangement is novel in several respects. The carriage, which is fed by hand, is carried on rollers, a plan that has often been attempted without success from the difficulty of keeeping it "square," the V track being the only thing that would accomplish the purpose.



In this machine, however, this object is secured by means of a shaft, seen under the carriage, on each end of which there is a pinion gearing into the rack, seen on the end rails of the carriage. These pinions being connected positively by means of the shaft, of course produce a coincident movement of each end of the carriage without offering the least resistance.

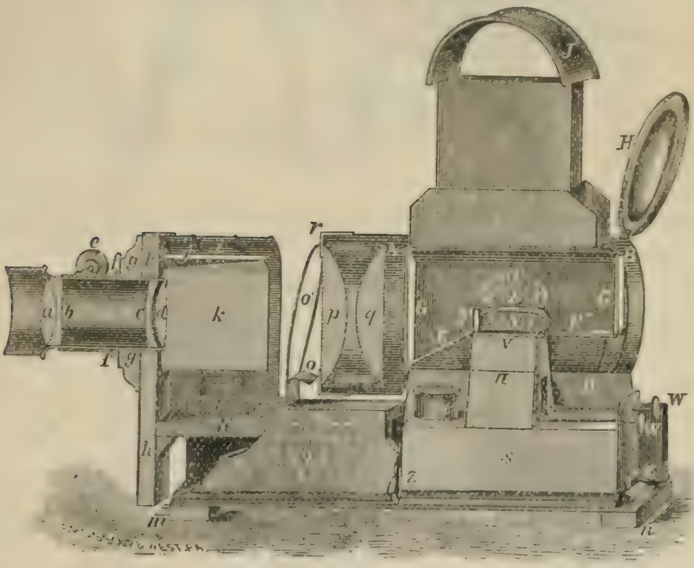
This device was employed some years since for a similar purpose in the Reading Railroad Company's works, at Reading, Pa., and is one of those simple and at the same time important things the importance of which bears an inverse ratio to its ingenuity, and involve the true principle of improvement in machines.

The cross rails on the carriage slide to any point on the cylindrical rails, and have spring stops or gauges to regulate lengths. The longitudinal rails are of wrought iron tubing, for lightness. All parts of the framing are made with corner section, including the heavy sole plate. We regret that the engraving is not in true elevation, but the detail is of such a character, and the parts fall so near in one horizontal plane, that the perspective view conveys a more complete idea, if not so correct a one, as a true drawing. The scale approximates $\frac{1}{2}''$ $= 1'$.

The Sciopticon.—This instrument, which is a very efficient form of magic-lantern, using a lamp in place of the lime light, has had a previous notice in this Journal, but has since received a number of minor improvements, which render it extremely convenient for use in schools or elsewhere where the oxy-calcium light is not to be obtained. Its effects are very satisfactory.

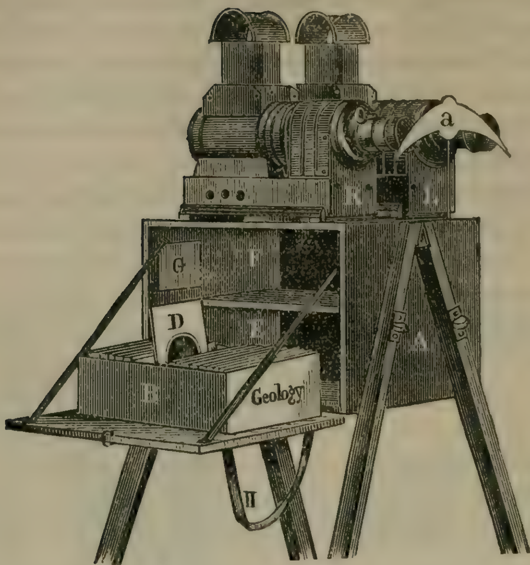
The illustration gives a view of the essential portions of the apparatus in section. *a b c d* are the lenses of objective, *p q* those of condenser; *o o'* is the stage for holding pictures; *s*, lamp cup; *w w*, buttons for regulating lamp; C I, ventilator and chimney; and H, reflector.

Fig. 1.



The necessity of having some form of the lantern, for object illustration, which should furnish a good illumination without the several inconveniences attendant upon the oxy-hydrogen light, is severely felt in many localities remote from cities, and even in these when the means or skill to operate the latter is wanting or troublesome to obtain. For such cases Mr. Marcy's compact and portable apparatus affords an admirable substitute, which we have no hesitation in recommending for simplicity, convenience and performance. Fig. 2 shows the stand and position of lanterns when used for dissolving views. When taken down the legs swing together on their hinges, and the

Fig. 2.



instruments occupy the spaces E F, the lid, C, serving as a shelf for the slides.

For those who have not observed our former notice, it may be said that the lamp, which is the distinguishing feature of the lantern, is supplied with petroleum oil, affording, by a simple arrangement, a long double flame, which is concentrated and drawn to a point by the form of chimney. The light is about two inches in depth in the ordinary form of apparatus, and is of extreme whiteness.

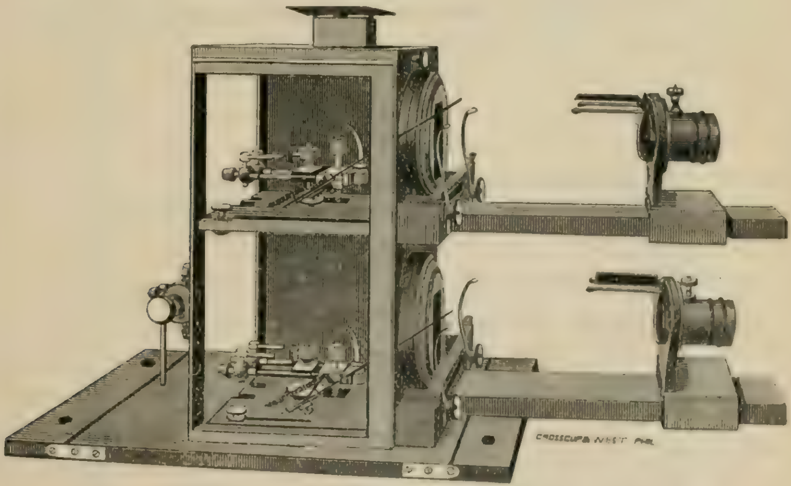
As the most satisfactory and convenient substitute for the oxy-hydrogen lantern which has yet been devised, the Sciopticon deserves to be known far and wide.

New Smelting Works at Pittsburg.—A furnace has been erected at Pittsburg for the smelting of silver ores of our Western States and Territories. It is greatly to be desired that this enterprise may prove successful enough to warrant the growth of works in our midst extensive enough to do all the work which now is done in Swansea, Wales.

The favorable situation of that city, from its direct railroad connections with the West, and the immediate vicinity of cheap fuel of excellent quality, point to it as the proper position for the inauguration of this enterprise.

Improvement of the Ohio River.—Those interested in this important measure and the engineers having it in charge, at a recent convention held in Cincinnati, after a discussion of the various plans of river improvement, have made a report, in which it is claimed that any system which would secure a channel depth of six feet throughout the year, would so enhance the value of property, increase population, multiply cities along its shores, and so cheapen the primary comforts of life that the question of cost should be a secondary consideration. As to the best method, they say that Congress should authorize an elaborate examination by competent engineers of the whole subject of river improvement in this country, testing the comparative merits of different systems. In relation to the work thus far finished, Col. W. E. Morrell, the engineer in charge, announced that much of it was experimental, and has done as much harm as good. The opinion was likewise expressed that little was to be profited by the experience derived from similar works in European countries, since the streams which have there been improved are small in size compared with the Ohio.

New Form of Stereopticon.—The accompanying engraving



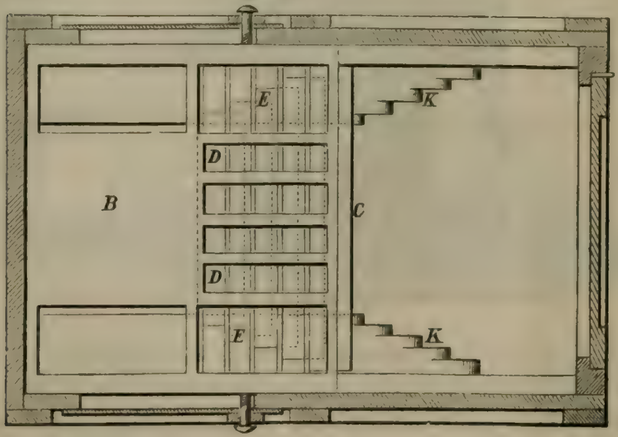
represents a form of lantern designed and manufactured by the firm of W. M. McAllister, of this city, and which possesses, for certain purposes, a number of conveniences. In the arrangement of lanterns one above the other for dissolving views much less space is occupied,

and the management of the lights rendered less troublesome than where the two are arranged side by side, as in the ordinary plan, since here both may be observed at once. The proper angleing of the lenses is accomplished by attaching both condensers with objective stands to the box in such a manner as to admit of motion in a vertical direction. The rods projecting through the front of box, connect with a pawl and rachet movement, by which the limes are turned at the insertion of each picture, thus dispensing with the cumbersome clock-work generally relied upon to do this work. The heating of the interior of box is avoided by the interposition of an air-space beneath the horizontal partition, the chimney being at the side. The apparatus is very complete, and being compact in form, is well adapted for school or exhibition purposes.

Wakefield Earth Closet.—The accompanying cuts represent horizontal and vertical sections of this contrivance. It is unnecessary for us to enter into the discussion of the merits of the earth closet system, or to present its great advantages, sanitarily, economically and æsthetically, for these matters have been decided long ago by the strongest endorsements of the chemist and physician.

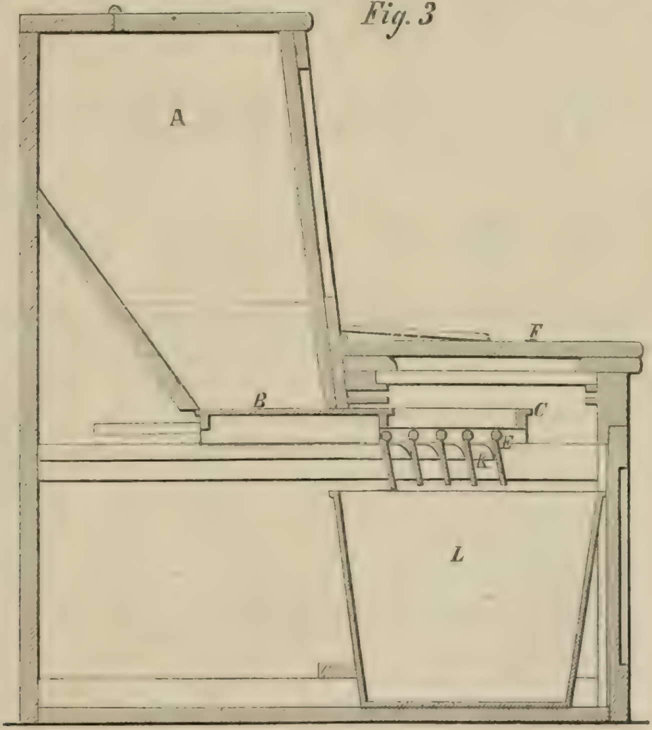
The following notice is a simple description of the construction of the machine. Figures 2 and 3 are respectively horizontal and vertical sections.

Fig. 2



A shows a reservoir for the reception of the earth (charcoal or other absorbent.) At the bottom of this chamber is placed a metallic slide, B, and when the commode is not in use this slide is drawn forward, as seen in Fig. 3, and forms a bottom to the chamber, A, fitting close to its edges. The front portion of this slide, as shown at C, consists of shallow chambers, D, which are recessed, and are closed by means of the pivoted slats as shown at E. In Fig. 3 these slats are shown

Fig. 3



as being dropped down, which position they assume by their gravity on being drawn forward a sufficient distance.

When the lid, F, is raised, a rod, G, actuates the lever, H, which is pivoted at I, near the upper portion of the chamber, A, and engaging the pin, J, which projects from the metallic slide, B, compels a backward motion of B, and brings the recessed chambers, D, under the chamber, A, when they are filled with earth. The slide, N, serves to close the slat underneath it in the chamber A, in which the pin, J, operates, and so prevents the escape of disagreeable odors. Earth is retained in the chambers, D, by the closing of the slats, E,

which are raised by becoming engaged with the steps, K, as the seat, F, is raised.

In closing the lid, a reverse of the movement described takes place. By the forward action of the rods, G and H, and the stud, J, the plate, B, is thrown forward, the slats, E, become disengaged from the steps, C, drop down, and the contents of the shallow recesses or chambers, D, are discharged into the bucket, L, covering its contents completely and with certainty. To prevent the rise of dust or offensive odor from L, there is a slide made to entirely close the opening in the seat.

The following are the dimensions of the Wakefield Commodes: 3 feet high to top of reservoir, 2 feet 7 inches from front to rear on the floor; 2 feet extreme width.

The apparatus is of convenient form, a view of which we will present in a future number, and may be inspected at the agency of the Earth Closet Company, 105 S. 4th St., Philada.

Removing Phosphorus from Iron Ores.—Mr. Julius Jacobi, Director of the smelting works at Kladno, Bohemia,* has invented a process of effecting the removal (and subsequent utilization) of the troublesome phosphorus compounds from iron ores; its efficiency in practice remains still to be tested. The process consists in changing the insoluble basic phosphates, as they exist in the ores, into soluble acid phosphates, and the subsequent removal of the latter by leaching.

The ores to be operated on are placed in an appropriate vessel, after being reduced to convenient lumps of moderate size, and a stream of water charged with sulphurous acid is allowed to run upon them, or a stream of the gaseous acid is forced through the mass, and cold water is at the same time turned upon it. After the greater part of the phosphates have passed into the solution, the liquid is drawn off, and fresh water is passed through the mass to wash it thoroughly—this operation being continued as long as phosphoric acid can be detected in the wash water. If much phosphorus exists in the ores, the operation with sulphurous acid must be repeated, until a sufficient degree of purity is reached.

The liquid containing the acid phosphates is heated to drive off the sulphurous acid, and the phosphates are again separated, partially by concentration, or by precipitation with lime. This being a valuable fertilizer, is relied upon to cover a large portion of the expense of the operation.

* Bai. Ind. u Gewerbe Blatt.

Sensitive Flames. By Isaac Norris, M.D.—The arrangement of Barry for rendering a flame sensitive is well known, and offers the great advantage of using the gas at the ordinary pressure, so that the experiment is arranged in a moment. The size of the pin-hole aperture determines the height of the flame burned above the wire gauze. I have found after many experiments that it is rendered much more sensitive by using a chimney,—an ordinary glass one, such as employed with the argand burner, answering perfectly and rendering the flame at the same time much more steady. It may rest on the gauze, which must be placed at the proper height above the burner. The gas should be burned on until it begins to flare, and then lowered a little until it becomes steady. The nearer it is to this point the more delicate the result. Tyndall's caution with regard to obstructions from stop cocks, etc., is also very important. Wishing to measure the height I attached a small scale to the chimney, and found, as recorded, that the flame is much more sensitive to some sounds than others. Any sound in which the letter s enters seems to affect it particularly. Attaching a telescope to the apparatus, something like the arrangement in a cathetometer, I found that even when the flame appears to the eye perfectly steady, it was continually varying in height—sounds that were quite inaudible to any one near it, evidently producing a marked result.

A tall flame, six or eight inches in height, is not as sensitive as one of only two or three inches, and placing the gas in a bag at the same pressure as it issues from the pipe did not alter the result. The whole subject is a very curious one, and I am inclined to think this flame is *the most delicate* yet produced, despite the accounts of the wonderful steatite burner of which Tyndall speaks. An illustrated description of Barry's sensitive flame appears in this Journal for January, and it is to be hoped the present little article may lead to other experiments in the same direction.

A New Hygrometer.—Mr. W. G. Whitehouse has communicated to the Royal Society a description of an instrument of this kind, of which the following is a short account:

It consists essentially of three thermometers of similar construction and used as a wet bulb, a dry bulb and an acid bulb respectively, placed conveniently side by side on a frame, and read together for comparison.

The acid bulb is arranged so that a regulated supply of strong sulphuric acid, free from lead and of uniform density, shall flow upon

the bulb (say about one drop per minute). This is accomplished by using a capillary siphon tube, properly adjusted for the delivery of the needful supply.

The action of the acid is to condense upon the bulb the moisture of the air, and to set free a certain amount of heat, dependent upon the quantity of moisture in the atmosphere, upon it, causing an elevation of the temperature. This elevation in temperature is strictly a measure of the amount of moisture in the air absorbed by the acid film spread upon the surface of bulb. The supply of concentrated acid is constant, as the hydrated acid passes off.

This form of instrument is identical in principle with the wet and dry bulb, the measurement being in either case a thermometrical one; but in the ordinary instrument the zero of the scale is reached in an atmosphere saturated with moisture, and its action depends upon the heat rendered latent by the evaporation from its surface; while the acid bulb thermometer is at its zero in a perfectly dry atmosphere, and depends for its action upon the amount of sensible heat evolved by condensation of water vapor on its surface and the heat generated by its combination with the acid. The instrument is pronounced to be of extreme delicacy.

Carburetted Air in Iron Manufacture.—It is stated that in certain smelting establishments in Europe, the experiment is being tried, and with success, of using air carburetted by passing over petroleum in the reduction of iron from its ores.

Measurement of Stellar Motion by the Spectroscope.—A very beautiful *acoustic* illustration of the method of determining stellar motions by the spectroscope was lately given by Prof. A. M. Mayer, in a lecture at the Sheffield Scientific School, which in its extreme simplicity is worthy of admiration.

The lecturer explained the effect of lengthening or shortening a wave, stating that in the case of a sound-wave (all of them moving at the same velocity), if the length be diminished, more vibrations enter the ear in a given time, and the pitch is raised; the reverse takes place on increasing the length. The lecturer then dwelt upon the analogy between the sound waves and those of light. Hence, whenever one of the colored waves composing white light is lengthened, its color is modified in the direction of the red end of the spectrum, and *vice versa*. The motions of a star when at right angles to the view is susceptible of telescopic measurement, but, the lecturer continued,

the motion of a star when in the direction of the line of sight can only be measured on the principle above named, the standard being the displacement from their normal position of certain lines in its spectrum. This principle the lecturer proceeded to illustrate by means of sound waves. With the lantern the image of a tuning fork beating 256 times a second—and giving a certain note—was thrown on the screen. By the side of one of the prongs, and just touching it, was a carefully rounded and varnished cork ball, suspended by a filament of silk. On sounding a second fork placed on its case and tuned in accurate unison with the first (by an ingenious method devised by Prof. Mayer) anywhere in the room, even 30 feet distant, the first was thrown into vibration and the image of the cork ball was projected a foot or two away from the prong. When, however, the second fork was sounded, and the lecturer walked rapidly—at a rate of 8 feet a second—towards or from the first, touching the case only when in motion, no motion of the cork was observed, the wave being in this way shortened or lengthened by an amount sufficient to throw it out of unison with the lantern fork. Again, a third fork, vibrating 254 times a second, produced no effect on the ball; but when sounded and placed on its case as this was swung rapidly toward the first fork, the wave length was thereby so shortened as to bring it into unison with this, and the ball promptly responded. A fourth fork, vibrating 258 times, showed the same phenomenon when placed on its case, as this swung away from the first fork, the wave thus being shortened into unison. The demonstration was most complete and satisfactory.

New Method of Obtaining Potassium.*—Prof. A. E. Dalbear describes a process for obtaining the metals potassium and sodium, which may prove, if properly tested, of commercial value. The sulphide of potassium was formed by treating dissolved sticks of caustic potash with sulphuretted hydrogen, and subsequently evaporating until the mass was solid on cooling. This mass was then mixed with somewhat more than its bulk of iron filings and subjected to distillation, the product being led into petroleum. The products used in the operation are cheap, and the process seems to be a very sensible one, and worthy of trial on the commercial scale.

Permanency of Photographic Silver-prints.—Our photographic contemporaries contain a communication upon this subject from Mr. Carey Lea, in which the author declares, that of a number

* Amer. Chemist ii. 297.

of photographic prints, toned by various processes, all of them, after being kept for seven years, proved to be permanent. The opinion is ventured that when silver prints turn yellow, the fault is to be ascribed to careless treatment, either in the introduction of too many pictures in small quantity of the fixing bath, or in imperfect washing; in either case the fault of the operator.

Products of the Explosion of Nitro-Glycerin.—M. L. L'Hote announces to the French Academy the following method of determining the character and relative proportions of the products formed in the explosion of nitro-glycerin.

The author substituted for the blow of the hammer, the blow produced by the explosion of a mixture of hydrogen and oxygen. A eudiometer tube of thick glass was supplied with a measured quantity of the explosive mixture (H and O), and a weighed quantity of the nitro-glycerin was inserted. The method adopted was to insert the material by a capillary tube into a very small bulb of thin glass, and to bring this, after careful weighing, up into the eudiometer. The passage of the spark and the shock of the combustion of the mixed gases, caused the explosion of the nitro-glycerin, and the breaking of the thin glass bulb. The products of the explosion collected in the tube could then be treated as in an ordinary gas analysis. By this method one gramme of nitro-glycerin was found to produce: 284 c. centm. of gas. Analysis by absorption showed this to consist, in 100 parts, of

Carbonic acid, ...	45·72 vols.
Nitric Oxide, ...	20·36 "
Nitrogen, ...	33·92 "
	100.00.

An Acoustic Experiment.—Let a wide glass tube, open at both ends, be taken, and in this a piece of fine wire gauze be pushed up some little distance. If the gauze is now heated to redness over an ordinary Bunsen burner, and then removed, it will shortly emit a shrill note, lasting from 5—10 seconds. The experiment we believe will be new to most of our readers, and has the merit of always going off. The author has not been named to us.

Civil and Mechanical Engineering.

THE LOCOMOTIVE ENGINE, AND PHILADELPHIA'S SHARE IN ITS EARLY IMPROVEMENTS.

By Joseph Harrison, Jr., M. E.

(Continued from page 174.)

Philadelphia mechanics, following the lead of their predecessors in the same field, entered with zeal into the Baltimore contest. An engine was built by a Mr. Childs, who had invented a rotary engine which in a small model promised good results, and an engine of about fifty horse-power on this rotary plan was built and sent to Baltimore for trial. A record of its performance cannot now be easily reached, but it is known that it was never heard of as a practically useful engine after this time.

The second locomotive built in Philadelphia, to compete at Baltimore, was designed by Mr. Stacey Costell, a man of great originality as a mechanic, and the inventor of a novelty in the shape of a vibrating cylinder steam engine, that had some reputation in its day, and has come down to our time in the little engine now sold in the toy shops for a dollar. The Costell locomotive had four connected driving wheels, of about thirty-six inches in diameter, with two six-inch cylinders of twelve-inch stroke. The cylinders were attached to right-angled cranks on the ends of a counter shaft, from which shaft spur gearing connected with one of the axles. The boiler was of the Cornish type, with fire inside of an internal straight flue. Behind the bridge wall of this boiler, and inside the flue, water tubes, were placed at intervals, crossing each other after the manner of the English Galloway boiler of the present day. The peculiar arrangement of this engine made it possible to use a very simple and efficient mode of reversement by the use of a disc between the steam pipe and the cylinders, arranged with certain openings, which changed the direction of the steam and exhaust by the movement of this disc against a face on the steam pipe near the cylinder, something after the manner of a two-way cock. It is not known whether this locomotive of Costell went to Baltimore or not. It is known, however, to have been tried on the Columbia road in 1843 or 1844, but its success was not very striking, and it was subsequently broken up. The boiler of the

Costell locomotive had very good steam-making qualities. It was used for a long time as a stationary engine boiler.

The third engine begun in Philadelphia for the Baltimore trial was after a design of Mr. Thos. Holloway, an engineer of some reputation forty years ago as a builder of river steamboat engines. This engine was put in hand, but never was completed.

Something was gained even by the failures that are here related, and these early self-reliant efforts show with what tenacity Philadelphia engineers clung to their early idea of building an original locomotive, and it will be seen hereafter that a type of locomotive essentially American was ultimately the result.

Whilst these movements towards the improvement of the locomotive were going on amongst us, the desire to have the railroad in every section of the country became more and more fully confirmed. The railway from New-castle to Frenchtown, sixteen miles in length, was finished in the winter of 1831 and 1832, and two locomotives, built by Robert Stephenson at Newcastle-upon-Tyne, were imported to be run upon this line, which made then an important link in the chain of passenger travel between New York and Washington. In this case, as in several others in the early history of the railroad in the United States, this new element came in as an adjunct mainly of the river steamboats, and was considered most useful in superseding the old stage coach in connecting river to river, and bay to bay.

That the railway would supersede the steamboat for passenger travel, and the canal for heavy transport, was not dreamed of in the early day of the new power.

When the English locomotives were landed at New-castle, Delaware, it became necessary to select a skilled mechanic to put them together as speedily as possible. Through the agency of Mr. Wm. D. Lewis, a most active Director of the Newcastle and Frenchtown Railroad Company, this task was assigned to Matthias W. Baldwin. These engines were of the most improved English type, and greatly superior to any that had then been made in this country. In putting these engines together Mr. Baldwin had all the advantage of handling their parts and studying their proportions, and in making drawings therefrom. This proved of great service to him when he received an order, in the Spring of 1832, to build a locomotive for the Philadelphia, Germantown and Norristown Railroad. This engine, called, when finished, the "Ironsides," was placed upon the above road in November, 1832, and proved a de-

cided success. Mr. Franklin Peale, in an obituary notice of M. W. Baldwin, writes, "that the experiments made with the 'Ironsides' were eminently successful, realizing the sensation of a flight through the air of fifty or sixty miles an hour." The "Ironsides," in its general arrangement, was a pretty close copy of the English engines on the New-castle and Frenchtown Railroad, but with changes that were real improvements. The reversing gear was a novelty in the locomotive, although the same mode had been long used for steam ferry boats on the Delaware. This arrangement consisted of a single excentric with a double latch excentric rod, gearing alternately on pins on the upper and lower ends of the arms of a rock shaft. This mode of reversing was used in the Baldwin locomotives for many years after the "Ironsides" was built. It is creditable to Mr. Baldwin as an engineer that the "Ironsides" was the first and last of his imitations of the English locomotives. He, following the bent of all the Philadelphia engineers and mechanics that had entered the field, aimed too, at making an American locomotive.

Following the success of this first locomotive, other orders soon flowed in upon Mr. Baldwin, and on these later engines many valuable improvements were introduced, of which mention will be made hereafter. Col. Stephen H. Long, nothing daunted or discouraged by the unsuccessful results of his first engine in 1831, renewed his efforts, and under the firm of Long and Norris, the successors of the American Steam Carriage Company, commenced building a locomotive in 1832, subsequently called the "Black Hawk." This engine, when finished, was run for some time on the Philadelphia and Germantown Railroad, and did good service in the summer of 1833, in competition with Baldwin's "Ironsides." The "Black Hawk" burnt anthracite coal with some success, using the natural draft only, which was increased by the use of a very high chimney, arranged to lower from an altitude of at least twenty feet from the rails, to a height which enabled it to go under the bridges crossing the railroad. In all of Col. Long's experiments he seems to have discarded the steam jet, or exhaust, for exciting the fire. The "Black Hawk" had several striking peculiarities beside the one just mentioned. The boiler was unlike any that had preceded it, in having the fire-box arranged without a roof, being merely formed of water sides, and in being made in a detached piece from the waist or cylindrical part. The cylinder portion of the boiler was made up of two distinct cylinders, about twenty inches in diameter, and these lying close together, were bolted to the rear

waterside and thus covered the open top, and their lower half-diameters thereby became the roof of the fire-box. A notch was cut half way through these two cylinders on their lower half diameters about midway of the length of the fire-box, directly over the fire, and from these notches flues of about two inches diameter passed through the water space of each cylinder portion of the boiler to the smoke-box. These flues were seven or eight feet in length. Besides passing through the flues, the fire passed also under the lower halves of the cylinder portions of the boiler, a double sheet iron casing filled between with clay, forming the lower portion of the flue and connecting it with the smoke-box.

The "Black Hawk" rested on four wheels, the driving wheels about four and a half feet diameter, being in front of the fire-box. The guide wheels were about three feet diameter. Inside cylinders were used, and these required a double crank axle, and the latter, forged solid, could not easily be had. Col. Long overcame this difficulty by making his driving axle in three pieces, with two bearings on each, and with separate cranks keyed on to the ends of each portion of the axle, with shackle or crank pins arranged after the manner of the modern side-wheel steamer shafts. Flanged tires of wrought iron could not then be had easily, and this was overcome in the "Black Hawk," by making the tread for the wheels of two narrow bands, shrunk side by side on the wooden rim, with a flat ring, forming the flange, bolted on the side of the wheel. Springs were only admissable over the front axle, and to save shocks in the rear, the after or fire-box portion of the boiler was suspended upon springs. The Camb cut-off, then much in vogue on the engines of the Mississippi steamers, was used in the "Black Hawk." With some slight alterations this locomotive was sent to a road in New England in 1834. Other locomotives, mainly after the design of the "Black Hawk," were built by Long & Norris, and by William Norris & Co., in 1834, but they were not greatly successful. With the firm of William Norris & Co. Col. Long retired from the manufacture of locomotives in Philadelphia, and his name was not thereafter heard of in connection with its improvement. On the retirement of Col. Long, William Norris, a gentleman then with no acknowledged pretensions as a mechanic or engineer, brought other skill to his assistance, and after several not very successful efforts with engines of a design more like those that had succeeded of other makers, brought out an engine, in 1836, called the "George Washington," the success of which laid the foundation of the large

business done for thirty years thereafter at Bushhill, Philadelphia, by William Norris, and subsequently by his brother Richard Norris. The "George Washington" was a six-wheel engine with outside cylinders, having one pair of driving wheels, 4 feet in diameter, forward of the fire-box, with vibrating truck, for turning curves, in front. This engine weighed somewhat over fourteen thousand pounds, and a large proportion of the whole weight rested on the single pair of driving wheels. This locomotive, when put upon the Columbia road (now Pennsylvania Central), did, apparently, the impossible feat of running up the old inclined plane at Peter's Island, 2,800 feet long, with a rise of one foot in fourteen, drawing a load of more than nineteen thousand pounds above the weight of the engine, and this, too, at a speed of fifteen miles per hour. This was no doubt impossible, if the simple elements of the calculation are only considered. But there was a point in this experiment, well known to experts at the time, which *did* make it possible, even by calculation; and this point consisted in the amount of extra weight that was thrown upon the drivers by the action of the draft link connecting the tender with the engine,—the result being that about *all* the weight of the locomotive rested upon the drivers, less the weight of the truck frame and wheels in front. This most extraordinary feat, a writer on the subject says, "took the engineering world by storm, and was hardly credited." The "George Washington, an outcrop of the earlier efforts of Col. Long, was unquestionably a good and well made engine, and greatly superior to any that had preceded it from the Norris Works. The fame this engine earned led to large orders in the United States, and several locomotives of like character were ordered for England and for Germany.

Improvements were made from time to time in the Norris locomotives—the establishment fairly holding its own with its rivals until the Norris Works ceased to exist about 1866 or '67. Mr. William Norris, the founder of the works at Philadelphia, at one time commenced the building of locomotives at Vienna, Austria, but with no very great success; and after his return ceased his connection with the Norris Works. At the epoch from 1833 to 1836, the Norris and Baldwin engines had each their advantages and defects.

"The Norris engine, as it was at the commencement of 1837, may be described as follows: The boiler was of the dome pattern, known in England as Bury's, and used by that maker in 1830; the framing was of wrought iron, the first made entirely of this material in this country; the cylinders were placed outside of, and were fastened

to the smoke-box as well as to the frame. The engine was supported on one pair of driving wheels, placed forward of the fire-box, and on a swivelling four-wheeled truck placed under the smoke-box. The centre of the truck being so much in advance of the point of bearing of the leading wheels in the English engines of that day, there was considerably greater weight placed upon the driving wheels in proportion to the whole weight, while it was not unusual to adjust the draw bar so as to throw a portion of the weight of the tender upon the hinder end of the engine when drawing its load. This engine used four excentrics with latches. Hand levers were used for putting the valve rods into gear when standing. The valve motion was efficient, as the performances of these engines fully attested."

The "Baldwin" engine of the same period had a similar boiler, and somewhat similar position of, and fastening of the cylinders. The driving wheels were placed behind the fire-box, the usual truck being placed under the smoke-box. These engines ran steadily, owing to their extended wheel base, although they did not have the weight on the drivers, and the consequent adhesive power of the Norris engine. The framing was of wood covered with iron plates, and was placed outside the wheels. The driving wheels had two outside bearings. The cylinders, although outside of the smoke-box, were placed so as to give a connection to the crank, inside of the driving wheels. The crank was formed in the driving axle, but instead of being made as a complete double or full crank, the neck, to which the connecting rod was attached, was extended through and fastened into a hole in the driving wheel, the distance from the centre being equal to the throw of the crank. A simple straight pin fitted to the centre of the wheel, and extending outwards, formed an outside bearing for the axles. This device of Mr. Baldwin's was most ingenious and efficient. It simplified by more than one-half the making of the crank shaft, and increased its strength, and at the same time caused the thrust of the cylinder to act close to the driving wheel inside, in the same manner as the outside crank pin. With the introduction of the outside cylinder, this mode of making a crank axle has gone into disuse. The guide bar for the cross-head, which had a double V top and bottom, was clasped by the cross-head, and being hollow and with valve-chamber attached, was made to serve the purpose of a force pump. The valve-gear, already described, was placed under the foot-board, and although efficient, was cramped for room, the excentric rods consequently being rather too short.

In workmanship and proportion of parts the Baldwin engine was the superior of the two class of locomotives that had then become, in their manufacture, an important feature in the trade of Philadelphia.

M. W. Baldwin in 1834 and 1836 had much the advantage of the Norris establishment, as he had had from the first, in being a good practical machinist himself, and in having had some experience in steam engine building previous to the making of the "Ironsides," in 1832; whereas William Norris, after Col. Long retired, in 1833–34, having then no engineering or practical knowledge of engine building, was left dependent entirely upon hired skill, which at that time, in the construction of the locomotive, was most difficult if not almost impossible to find. Mr. Baldwin had also the great advantage of better workshops and better tools at the commencement of this new business than his early competitor: hence his success was at once more decided, and the improvements in his locomotives, both in design and in workmanship, much more important from the beginning. It is needless to speak to this audience of the "Baldwin Locomotive Works" of to-day. With a record of forty years, during the early years of which it passed successfully through many vicissitudes, it maintains its well-earned character of the first locomotive manufactory, both in quantity and quality, in this country; and it is doubtful whether it is not now the equal to, if not the superior, in these particulars, of any establishment doing similar work in the world.

The Baldwin engine of 1836, with its driving axle behind the fire-box, was steady at high speeds, but with insufficient adhesion to the rails.

The Norris engine, of the same date, having a great proportion of the weight overhanging the driving axle, although having adhesion equal to its cylinder power, was unsteady on the rails. Improvement rested between the two systems of Baldwin and of Norris.

In the spring of 1835 the firm of Garrett and Eastwick, then making steam engines and light machinery in Philadelphia, commenced the building of a locomotive engine for the Beaver Meadow Railroad. This firm, having no practical knowledge of this new machine, called to their assistance, as foreman, Mr. Joseph Harrison, Jr., a young man of twenty-five, and a good practical workman, who had been employed for nearly two years as a journeyman in the Norris works, and had been schooled, during that time, amidst the indifferent successes or real failures of Long and Norris, and Wm. Norris & Co. The first locomotive designed under the above auspices was called, when finished, the Samuel D. Ingham, after the President of the road.

It had outside cylinder connections, then not much in vogue,—running gear after the Baldwin type, with one pair of driving wheels behind the fire box, and with four wheel truck in front. It had the dome or "Bury" boiler. This engine had some points about it which differed from any locomotive that had preceded it. Its most distinguishing feature was an ingenious and entirely original mode of reversement, invented and patented by Mr. Andrew M. Eastwick, the junior member of the firm. It is scarcely possible to give a correct idea of this device without a model or drawings, but its principle consisted in the introduction of a movable block or slide, called a reversing valve, between the usual slide valve and the opening through the cylinder face. This reversing valve had an opening through it vertically for the exhaust, and two sets of steam openings, corresponding, when placed opposite thereto, to the openings on the cylinder face. One set, called direct openings, passed directly through the valve, and when set for going forward, made the usual channels to the cylinder. The second set of openings through the reversing valve, called indirect openings, and coming into play when the engine moved backwards, passed from the upper surface of the valve but half way through it, and thence were diverted laterally to the side of the valve, and thence along the side and again laterally, came out of the under side where the reversing valve rested against the valve face of the cylinder, directly opposite a second indirect opening on the upper surface of this valve. When the reversing valves were set for going forward, the direct openings were placed exactly over the steam openings on the cylinder, whilst the indirect openings came over the solid surface of the cylinder face, and were then entirely out of use. The exhaust opening through the reversing valve in this case, came directly opposite the exhaust opening on the cylinder. The slide valve, never detached from the excentric, moved over the direct openings in the usual way. Moving the reversing valve to the opposite end of the steam chest from where it had been placed in going forward, and the case was different. Then, steam entering the reversing valve at the upper side, instead of going directly into the cylinder as before, was diverted in the manner just described, and came out at the cylinder face at the opposite end from whence it had entered on the slide valve face, on the upper side of the reversing valve, and thus the direction of the engine was changed from forwards to backwards, or *vice versa,* without detaching or re-attaching any of the moving ports of the valve gear. The principle and action of Mr. Eastwick's invention may be

EASTWICK and HARRISON'S LOCOMOTIVE.

MANUFACTURED AT THEIR WORKS, TWELFTH AND WILLOW STREET RAILROAD.

PHILAD'A, 1842.

guessed at from what has been described, although its detail may not be so easily made out. This new arrangement, neat and efficient as it was, had its defects, which no doubt interfered with its general use. It increased by the thickness of the reversing block, the length of the steam openings, in going forward, and further increased their length in going backwards. It also prevented the use of a long lap on the slide valve, for, any lead of the excentric in going forward, causing a corresponding delay in receiving steam in moving backward. In reviewing these defects, the beauty and originality of Mr. Eastwicks' device must not be overlooked. Nothing for the same purpose, so novel in its mode of action had preceded, or has succeeded this invention of a Philadelphia mechanic, and it is doubtful whether any locomotive has since been made with so few moving parts as this first engine of Garrett & Eastwick. This engine had for the first time, the rear platform covered with a roof to protect the engineman and fireman from the weather.

The success of the "Samuel D. Ingham" was quite equal to any locomotive of its class that had been built up to that period in Philadelphia, and orders came to the makers from several sources for others of the same kind.

In 1836, Henry R. Campbell, of Philadelphia, "in order to distribute the weight of the engine upon the rails more completely, patented the duplication of the driving wheels, placing one pair behind and one pair in front of the fire-box, using the swivelling truck in front, of Baldwin's and others. Mr. Campbell subsequently made an engine after his patent, which was tried on the Philadelphia and Germantown Railroad, and although not a decided success, it was a great step in the direction in which improvement was most needed. Its principal defect consisted in its having no good means of equalizing the weight on the driving wheels so as to meet the undulations in the track. To remedy the defects in the Baldwin, Campbell and Norris engines, Garrett & Eastwick (soon thereafter changing their firm to Garrett, Eastwick & Co., Joseph Harrison, Jr., becoming the junior partner) commenced in the winter of 1836–7 a new style of locomotive, for the Beaver Meadow Railroad Company. Adopting the Campbell plan of running geer, they aimed towards making a much heavier engine for freight purposes than had yet been used. This could be only rendered possible on the slight roads of the country, at that time, by a better distribution of the weight upon the rails. In the first of the improved engines made by Garrett

& Eastwick for the Beaver Meadow Railroad, Mr. Andrew M. Eastwick introduced an important improvement in the Campbell eight wheel engine, for which he obtained a patent in 1836. This improvement consisted in the introduction under the rear end of the main frame of a separate frame, in which the two axles were placed, one pair before and one pair behind the fire box. This separate frame was made rigid in the "Hercules," the first engine in which it was used, and vibrated upon its centre vertically, and being held together firmly at the ends, both sides at all times moved in the same plane, thus only accommodating the undulations in the track in a perfect manner when the irregularities were on both rails alike. The weight of the engine rested upon the centre of the sides of this separate frame through the intervention of a strong spring above the main frame, the separate frame being held in place by a centre pedestal bolted to the main frame, the centres of the frame vibrating upon a journal sliding vertically in this centre pedestal. Mr. Eastwick's design was, however, somewhat imperfect, in not accommodating the weight of the four driving-wheels to the irregular undulations no both tracks. There were other minor improvements in the "Hercules," one of which was the introduction for the first time into steam machinery of the bolted stub-end instead of the old-fashioned and unsafe mode of gib and key for holding on the strap. This device, an idea of Mr. Harrison's, is now universally used in the connecting rods of the locomotive engine. The "Hercules," when put at work on the Beaver Meadow Railroad, proved a great success, and led to other orders for the same class of engine. This division of the weight on more points of the road, and its more perfect equalization thereon, seemed at the time, as it has proved since, to have been the commencement of a new era in the history of the locomotive. To remedy the defect, as before mentioned, in these first eight-wheel engines incident to Mr. Eastwick's plan, an improvement was patented, in 1838, by the junior partner of the firm of Eastwick & Harrison. Mr. Harrison's patent showed many ways of carrying out the principle of his improvement, but the one preferred consisted in placing the two driving axle bearings in pedestals bolted to the main frame in the usual manner, and by the use of a compensating lever above the main frame, vibrating on its centre, at the point of attachment to the main frame, the ends of the lever resting on the axle-boxes by means of pins passing through the frame. These levers vibrated on each side of the engine separately, and thus met all the uneven-

ness in both rails within a certain prescribed limit, which was governed by the play of the axle-boxes in the pedestals. This arrangement of Mr. Harrison was simpler, lighter and cheaper than the one that had preceded it, and was used in all the eight-wheel engines built by Eastwick & Harrison after the second one. In all engines now built in this country or in Europe with more than six wheels this device of Mr. Harrison is used in one or other of the different ways indicated in his patent.

In the summer of 1839, Eastwick & Harrison received an order from the Philadelphia and Reading Railroad Co., through the Chief Engineer, Mr. Moncure Robinson, for a freight engine that had peculiar points. This engine was designed generally upon the "Hercules" plan, but it was stipulated in the contract that the whole weight should be *eleven tons* gross, with *nine tons* on the four driving-wheels. It was also stipulated that it should burn anthracite coal in a horizontal tubular boiler. To distribute the nine tons on the driving-wheels, the rear axle was placed *under* the fire-box, and somewhat in advance of its central line, instead of being behind the fire-box, as in the "Hercules." This arrangement of the rear axle permitted nine tons of the whole weight of the engine to rest on the four driving-wheels. The boiler was of the Bury type, and the fire-box had the then unprecedented length, outside, of five feet. The tubes, two inches in diameter, and only five feet long, were more numerous than usual, and filled almost to the top, the cylinder part of the boiler. Cylinders 12½ inches in diameter, 18-inch stroke, using no cut-off; driving-wheels 42 inches. The Gurney draft-box was used with many small exhaust-jets, instead of one or two large ones. It is believed that this engine used for the first time the steam jet for exciting the fire when standing. The engine here described, called, when finished, the Gowan and Marx, after a London banking firm, excited much attention in the railroad world by its great tractive power, compared with its whole weight. On one of its trips (February 20th, 1840) it drew a train of *one hundred and one* four-wheel loaded cars from Reading to Philadelphia, at an average speed of 9·82+ miles per hour, nine miles of the road being a continuous level. The gross load on this occasion was 423 tons, not including the engine and tender, which, if the weight of the tender is counted, equalled *forty times* the weight of the engine. See "Journal of the Franklin Institute," 1840, vol. 25, page 99, Report of G. N. Nicols, Supt. Philadelphia and Reading Railroad, which closes as follows: "The above performance of an eleven-ton engine

is believed to excel any on record in this or any other country." It may be doubted whether it has ever been excelled since. How strangely this feat of the Gowan and Marx compares with the trials on the Liverpool and Manchester Railroad in October, 1829, when all that was required of the competing locomotives was, that they should draw about *three times* their own weight, tender included, on a level track, five miles long, specially prepared for the trial.

In 1840 the Gowan and Marx attracted the particular attention of the Russian engineers, Colonels Melnikoff and Krafft, who had been commissioned by the Emperor Nicholas to examine into and report upon the various systems of railroads and railroad machinery, then in operation in this country and in Europe. The result of their examination was favorable to the American system, and when the engineers above named, made their report on the construction of a railroad from St. Petersburg to Moscow, an engine upon the plan of the Gowan and Marx was recommended as best adapted to the purposes of this first great line of railroad in the Empire of Russia, and Eastwick and Harrison were requested to visit St. Petersburg with the view of making a contract for building the locomotives and other machinery for the road. Mr. Harrison went to St. Petersburg in the spring of 1843, and in connection with Mr. Thomas Winans, of Baltimore, a contract was concluded with the government of Russia, at the close of the same year, for building 162 locomotives, and iron trucks for 2,500 freight cars. Eastwick and Harrison closed their establishment in Philadelphia in 1844, removing a portion of their tools and instruments to St. Petersburg, and there, under the firm of Harrison, Winans and Eastwick, completed, at the Alexandroffsky Head Mechanical Works, the work for which they had contracted, much additional work during the progress of the contract, being added thereto. The first contract was closed in 1851, at which time a second contract, by two members of the firm, for the repairs to the rolling stock of the St. Petersburg and Moscow Railroad, was entered into, which continued until 1862.

The eight wheel locomotive of Eastwick and Harrison, made its first reputation as a freight engine only. In 1842, two of these engines were built by E. and H. for the Baltimore and Ohio Railroad, which were specially designed for running passenger trains at extra fast speed. One of these engines, during the year 1844, ran the large aggregate of 37,000 miles, which, by the annual report of the Baltimore and Ohio road for that year, is assumed to be the largest

result on record up to that time. The locomotive of the Hercules type, and those that immediately followed it from the same makers, is now the standard engine for passenger trains in this country, and is being introduced in Europe for the same purpose, but it is not now used generally as a freight engine.

In the years following the early efforts of Baldwin, Norris, Campbell and Eastwick and Harrison, other Philadelphia engineers and machinists entered the field in the manufacture and improvement of the locomotive. Mr. Henry R. Campbell built several very creditable six-wheel engines. James Brooks & Co., aided by Mr. Samuel Wright, a young man of good practical skill, constructed a locomotive which had several new points worthy of notice. Its running gear was after the type of the six-wheel engine of Baldwin, with one pair of driving wheels behind the fire-box, and with outside cylinder connections. The cross-head slides were made in the form of a cylinder, bored out and arranged to serve the purpose of feed-pumps, the cross-head forming the piston of the pump. The connecting rod entered the lower or open end of the slide, which was large enough to allow clearance at the angles of the rod. The usual valve chamber was placed at the upper end of the slide and thence a pipe led to the boiler. This mode of arranging a feed pump was more ingenious in design than useful in practice, and was not repeated in a second engine built by the same makers. A second point in the Wright engine was the mode of reversement, which was the same in principle as the Costell plan. The slide valve was open through the top, from the exhaust cavity underneath, and terminated in a cylindric form in which was fitted a metallic spring-piston closing up the opening through the valve. When the engine was going forward, steam from the boiler entered the steam chest, and the slide valve acted in the usual manner. When going backward, by the peculiar arrangement of a slide valve which acted also as a steam or throttle valve, the steam from the boiler, by a process similar to a two-way cock, was turned under the cylinder slide valve and into the cavity of the exhaust, forcing the piston in the top of the valve, upward and against the evenly planed under surface of the steam chest lid, the exhaust pipe becoming the steam chest, and the steam chest the exhaust pipe, and *vice versa* when the movement of the engine had to be changed.

This mode of throttle valve and reversement valve in one, combined with the piston slide valve, was a most simple and certain arrangement. It had, with Costell's, the same defect in the matter of the lead

of the slide valve as the Eastwick mode of reversement. Eastwick and Harrison made two locomotives in 1838, with vibrating valves moving on faces on the side of fixed cylinders, reversing Costell's plan. In these two engines the throttle valve and reverse were combined in the same manner as in the Wright and in the Costell engine, by the movement of a slide valve moving over three openings.

With the second engine of James Brooks & Co., also designed by Samuel Wright, an attempt was made to secure the adhesion of the forward swivelling truck wheels in combination with one pair of driving wheels behind the fire-box, which worked with fair practical success. This same idea was carried out by Mr. Baldwin at, or near this period. James Brooks & Co. did not continue the building of locomotives after this second trial. About this time, Messrs Charles & Escoll Sellers, of the firm of Coleman Sellers & Sons, of Philadelphia, built a locomotive somewhat after the plan of the Baldwin engine. It is not remembered that this engine had any specially original points except in the arrangement of the draw-link between the engine and tender, whereby the point of attachment to the engine could be raised or lowered, so as to bring more or less of the weight of the tender for increasing the adhesion of the driving wheels. Mr. Escoll Sellers, some years later than this, invented and patented the plan of central rail, with vertical friction rollers, the same as has been used up to a recent period on the "Fell" railroad crossing Mont Cenis, before the completion of the tunnel. Edward Young, at Newcastle, Delaware, and Leonard Phleger, Philadelphians, also made improvements in the locomotive.

In 1846 Septimus Norris, a brother of Wm. Norris, patented a ten wheel locomotive with six driving wheels, combined with swivelling truck forward. Several of these engines were built for the Philadelphia and Reading Railroad. It is true that from amongst all these pioneers in the manufacture and improvement of the locomotive engine, the Baldwin Locomotive Works only remains in Philadelphia at this time. But the fact that the smaller establishments exist no longer, should not cause the workers in the early day to be forgotten. They helped to attract the attention of the railway world towards Philadelphia as the great source of supply for railroad machinery, and in this they helped also to make it possible for us to have to day, the great locomotive establishment, which is now the pride and boast of Philadelphia.

The story has now been told of what Philadelphia engineers and

mechanics have done at home, in the early and later day, in the development and improvement of the locomotive engine. This record would not be complete without some reference is made to that which they have done outside of Philadelphia. These workers can be found everywhere, and for nearly forty years Philadelphia skill has been sought for to fill responsible places in all parts of the United States, in the West Indies, in South America and in Europe, and even in British India.

In tracing this history from the date of Colonel Long's first effort to the period at which the locomotive has reached its present perfection, it cannot but be noted how persistently and tenaciously Philadelphia mechanics and engineers clung to the early idea of making an engine that should have important original traits, and it is further remarkable that in no single instance has there been even a desire to merely repeat what had been done elsewhere. The eight-wheel engine of Campbell,—first conceived by him in 1836, and with the added improvements of Eastwick and Harrison in 1836 and 1837, subsequently copied by Baldwin, Norris and all other makers, is to-day, after more than thirty years of trial, with but little change except in its greatly increased weight,—the passenger locomotive of this country. Baldwin, Norris and others did much toward the improvement of the freight engine, and have earned a well-merited reputation in its construction, which the present proprietors of the Baldwin Locomotive Works most manfully maintain. Take the best locomotives now made in the United States, and it will be difficult to find one that has not upon it some distinct impress of a Philadelphia mechanic, and it may be fairly claimed that they have made a mark upon this most important and useful machine that is eminently Philadelphian.

In the long future, when the story of the locomotive is inquired into and rehearsed by the curious, as it will be, Philadelphia's honors fairly earned, will not be overlooked, nor should the names of those who have aided in earning this honor be forgotten.

It is not only in the improvement of the locomotive that Philadelphia engineers and mechanics excel, but they are widely known and appreciated as the designers and manufacturers of all other kinds of railroad machinery. They are particularly noted for perfection in machines and instruments used in building the locomotive engine.

The ordinary observer, in looking at the perfect locomotive of the present day, and the perfect means in material and in instruments,

which render it now so easy to make it what it is, bestows little thought upon the amount of labor, both of brain and body, that has been expended in bringing it to this perfection. It is plain from the record, that there was no Royal road to the end attained.

The story of the railroad has been in part told in this history, and it is shown in how little estimation it was held up to near the close of the decade ending with 1830. Its present value is patent to every one, and it looms up as something so vast as almost to disarm discussion. But this value remained almost entirely latent from the time the first iron rail was laid down until the improvements in the locomotive in 1829. From that time the railroad took the place it fills to-day, a result only made possible by the little machine that we now see glinting in the sunlight as it crosses field and meadow with its lengthened train,—that we hear in the darkness of midnight, and that even now is threading its way in Cimmerian gloom through the Alpine tunnel, with a mile of rock above its head, making it possible to change the dreary cold of winter to the summer glow of an Italian sky in less than one short hour. It was this little machine which never tires in its work, and which we never tire in the looking at; that evoked the latent spark, toward which the student turns from his books, the ploughman stays his team, and the mechanic, the mother and the playful child, stop in their pursuits, to gaze and wonder as it passes by,—not once nor twice, but ever, as it speeds along, they stop and wonder as at something new and never seen before.

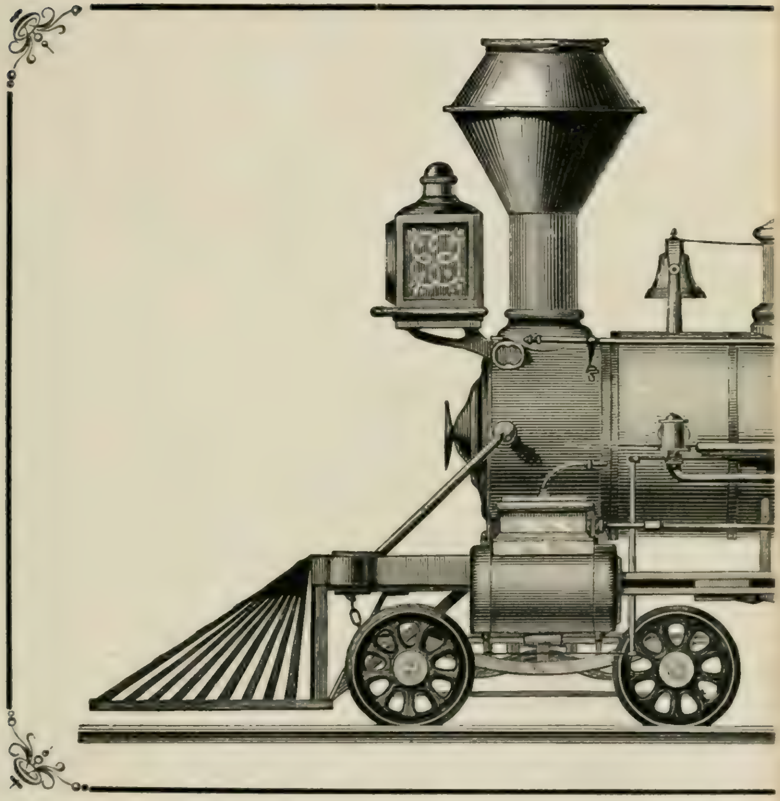
It is this wondrous steed,

"With iron nerves, and lungs of fire."

that has made the railroad what it is, that has won this triumph over Time and Space.

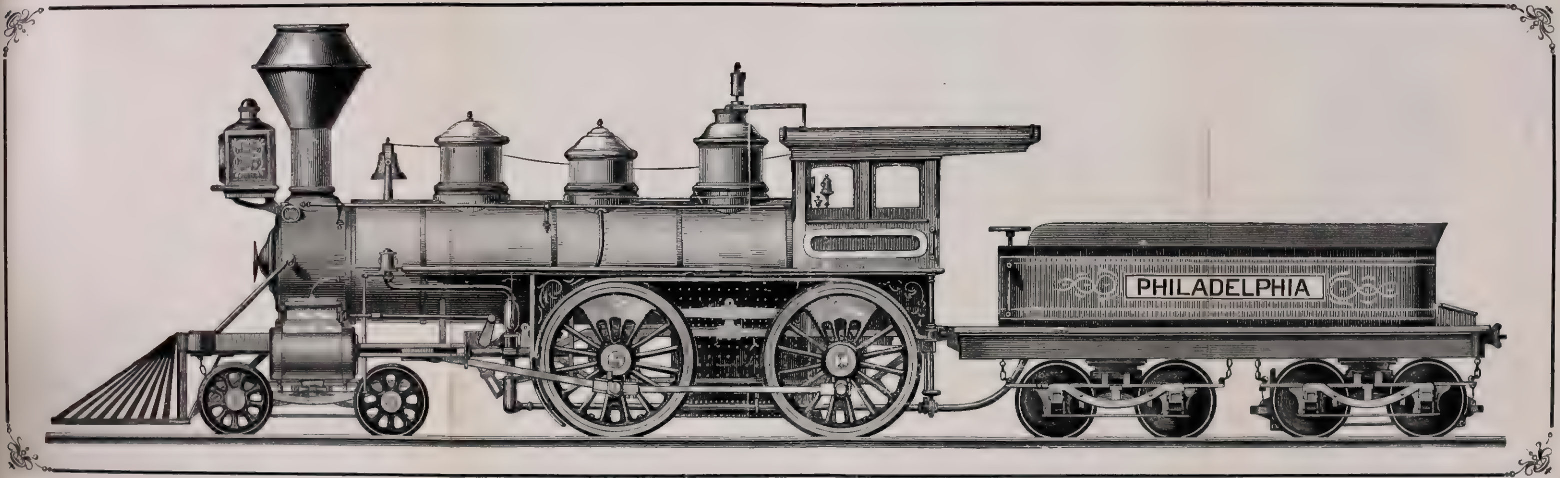
Philadelphia, December, 1871.

An Experimental Gas Works.—The German Society of Gas and Water Experts have under consideration a plan for establishing an experimental gas works, for the purpose of deciding various questions which may arise in the details of their profession, by actual experiment. The proposed plan, if adopted, will be upon a large scale, so as to reproduce, as far as possible, all the conditions met with in practice.



BALDW

Nothing was done on this dam until the 6th of November, from which



PASSENGER ENGINE.

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA.

BUILT BY M. BAIRD & CO., 1872.

Nothing was done on this dam until the 6th of November, from which

KEOKUK AND HAMILTON BRIDGE.

By Joseph S. Smith, Resident Engineer.

(Continued from page 195.)

Construction of the Work, Delays, &c.—A change in the first arrangement of the spans having been decided on, in order to leave a clear water-way of 160 feet on the square for the draw span channels, final plans were prepared early in June, 1869. In order not to be delayed for stone during the extreme low water season, when navigation on the rapids becomes very uncertain on account of the many shoals, large quantities of the stone were brought down and piled on the levee for use in the construction of the levee abutments and walls of the approach. In fact everything promised busy times for all connected with the work, but the unusually high water season extending over the months of April, May and July, part of August, all of September and October, and a part of November, seriously retarded operations, so that work in the river had to be postponed to the following season. In the meanwhile the available time was turned to account; grading was commenced on the eastern approach in March, but the spring rise early in April flooding the borrowing pits, compelled the contractors to suspend operations; and it was not till late in November that any amount of work was done on it, although twice attempted, once in June and again in August, during low stages of water. Grading on the western approach was begun during May, but only completed during October, operations being suspended during June, August and September. The western levee abutment, with its foundation carried down 17 feet to the rock, through the old *débris* of sticks of oak, rip-rap, scrapings of steamboat furnaces and other material deposited during the early days of Keokuk, was completed early in June during a low stage of water, and on the 15th the contractor commenced placing the coffer-dam for the eastern abutment of the main bridge. Although pumping out was commenced early in July, it was the 6th of August before the excavation for the foundations could be got at. The first stone was laid August 12th. On the 19th the high water flooded everything; the dam having been raised above the flood, work was resumed on the 21st, and two courses laid on the south wing by the 23d, when operations were again suspended by the "Father of Waters," who seemed determined during the entire time of construction to prevent it in one way or another. Nothing was done on this dam until the 6th of November, from which

time until the 9th of December the masonry was pushed ahead, but not finally completed until March of the following season. The coffer-dam necessary for the western approach masonry and western rest pier was begun in December, 1869; it was 260 feet long, by an average width of 105 feet. It was pumped out 23d of January, 1870. Masonry commenced on 8th of February. Being favored with a splendid building season during the usually rigorous months of February and March, the masonry was raised above the water level of the river on the 8th of March, and the dam allowed to fill to save labor in hoisting material. We were not yet out of the reach of the water, for the spring flood, beginning on the 19th of March, after a lively race between the masons and the rising water, flooded the greater portion of the work by the 30th of March. Being well advanced by the middle of May, and the river once more at a favorable stage, it was determined to push the construction of the piers. Accordingly, the coffer-dam for the first pier from the eastern shore was placed in 12½ feet of water on the 20th of May—a few days over eleven months since the adjoining abutment had been commenced.

The system devised for securing an anchorage on a rock bottom with but few fissures, and no certainty of holding an anchor long enough to build cribs in place as a protection against rafts, and obtain slack water for the construction of the dams, although not original, may not be uninteresting, and was as follows: A small scow or lighter was first anchored at the pier site, its position being determined by triangulation; the diver's scow, with pumping apparatus, &c., was securely anchored (often with a great deal of labor and loss of time from dragging of anchors) about 60 feet above the first lighter and in the line of the pier axis; a hole was then jumped into the bed rock of the river from this scow, with a long drill passing through a large-sized gas pipe, the diver directing operations at the bed of the river, and preventing the hole filling with the shifting sands. Into this hole was then securely fastened a bolt with a clevis and chain attached, and the placed marked with a buoy. Having now something to fasten to, it was an easy matter to construct cribs and fill them with stone, and in the slack water below to put together coffer-dam frames. Five of these anchor bolts were required, on an average, to each pier. When the frame of the dam was all ready it was set in place by triangulation, with one instrument on the bridge line, then sunk to place, sheeted, and filled above the water level. When pumped out and ready for the masonry, the distance was accurately

measured with a steel wire under strain, measured on a spring balance sufficient to swing it clear of the river, the span length being tested from previous established distances, and the pier axis turned off with an instrument, thus insuring the parallelism of the piers at the required distances.

The protecting cribs were built in two parallel courses, 10 feet apart between out and inside timbers, of 12 x 12 pine timber, half notched into each other at the up-stream point and shoulders, with cross ties also notched into the side timbers, leaving spaces between of six inches, and the whole well bolted together with long bolts reach-through all the timbers. The form of the up-stream end was a right angle; the sides below the shoulders were not parallel with the axis of the pier, but were somewhat flared to receive and protect the coffer-dam and afford protection to barges or floating derricks during the construction of a pier. When sufficient timbers were placed to reach the bed of the river, a course of heavy plank was laid at the water level, and the whole crib well weighted down with stone. So soon as the masonry was well above water these cribs were easily removed to another pier site.

The form of the coffer-dams corresponded to that of the piers, except that the down-stream end was straight. The clear space across the dam between side timbers was 20 feet, leaving 5 feet in the clear of the masonry at foundation courses. The outside and inside timbers of the sides were of 12 x 12 pine, in three courses, vertically three feet apart, securely bolted to vertical posts placed 8 feet apart on the outside of the side timbers, and resting on the bed rock when the frame was loaded down in correct position. The sheet piling was of 2″ pine plank, spiked on to the horizontal timbers after being driven well down on to the rock to broom up the ends. A clear space of seven feet was thus left, which was well puddled. Long bolts, $1\frac{1}{4}$ in. diam., with nut and washer on each end, reaching through the side and vertical timbers, tied the frame well together. This form of dam answered very well in from 8 to 16 feet of water.

The first stone was laid in the first pier from the eastern shore June 15th, and the last in the coping of rest pier was laid Dec. 3d, 1870. During these five and a half months eleven piers were built, containing 4282 cubic yards of masonry, or one every two weeks—a daily average of 30 cubic yards, including time occupied in preparing dams, cribs, &c., for foundations. The summer season was an unusually hot one, the thermometer for forty days averaging 100° in the

shade at mid-day, and was very trying on all. Although the work was done during the favorable building periods of two seasons, yet with an ordinary season it could have been completed in the required time.

Spans.—The general arrangement of the spans is as follows: Commencing from the Iowa shore, where the main channel of the river is, the dimensions of that part of the bridge are fixed by the Act of Congress, and call for two fixed spans of 250 feet for the passage of rafts, and of a pivot draw having two openings of 160 feet in the clear. The remainder of the bridge was divided into eight fixed spans, that being the most economical arrangement determined by the ratio of cost between span and pier. The final arrangement of the spans was as follows: The draw span is, from centre to centre of rest piers, 378′ 9¼″, leaving a clear water-way on both sides of the pivot pier of 160 feet, measured on the square with the pivot pier protections, and is the longest draw-span yet erected on the Mississippi River. The adjoining fixed spans are one of 257′ 1⅛″, one of 256′ 6″, leaving a clear water-way of 250 feet for the passage of rafts; then follow three spans of 162′ 9″ each, one of, 151′ 4″, then three of 164′ 7″ each, and one to the centre of east abutment, of 163′ 7″—all measured from centre to centre of piers, making the total length of superstructure 2188′ 9⅛″, and from back wall of western rest pier to back wall of east abutment 2192 feet.

Superstructure.—The superstructure was contracted for by the Keystone Bridge Company, of Pittsburg, Pa., and is the well-known Linville & Piper wrought iron bridge, a quadrangular girder with double intersections. The designs for the superstructure were furnished by J. H. Linville, C. E., the drawings being carefully worked up under the direction of Mr. M. Benner, at Pittsburg. It is a through bridge, on a skew of 17¼°, with a distance of 21′ 6″ from centre to centre of trusses, having a single line of railway track and two tramways for local traffic, the track being placed in the centre between the tramways. On each side of the bridge, outside of the trusses, are footwalks, 5 feet wide, protected by light and substantial iron lattice railings, and are supported by the floor beams, which are extended beyond the trusses for this purpose. The floor is planked throughout with oak. The depth of truss for the short spans is 21 feet from the centre of the lower chord to the top of the upper one, and for the longer spans is twenty-seven feet. The under side of the chord is placed 10 feet above the level of high-water mark of 1851, the high-

est water known at this point. The lower chord of the fixed spans is formed of wrought iron bars, with pin connections. The bars are made by upsetting the ends of flat bars of rolled iron till an increase of section is obtained, then the hole for the pin is drilled, thus avoiding the possibility of defective welds. The upper chord is formed of two channel beams outside, with two I beams between them, 9 inches deep, placed side by side and united by a plate rivetted to their upper flanges. The width of chord is 22 inches for the short spans, and two feet for the long ones. The posts are of wrought iron, of the Linville pattern; the sections are rivetted close together, at top and bottom, but separated at the centre, with ferrules on the rivets, thus offering facility for painting both out and inside. The intermediate posts rest on cast iron pedestals, with a gib block between the pedestal and floor beams; the end posts rest on cast iron pedestals, and these on cast iron wall plates, extending across the pier; at one end of each span a set of rollers is placed between the pedestal and wall plates, to provide for the expansion of the material. The ties are of square iron, with a welded loop at the lower end, passing around the pin. The upper end is provided with a nut, resting on cast iron angle blocks. The ties have also upset ends, and the section is not reduced by having the thread cut on it. The floor beams are suspended with four rods of four square inches area each, two under each post, passing through a heavy cast iron washer, and secured with nuts. The floor beams are formed of two 10-inch channel beams, well trussed with two rolled plates of iron, $4\frac{1}{2}'' \times 1\frac{3}{8}''$ each, and are $35'\cdot5''$ long. The draw span is similar to those erected by this Company at Dubuque and Kansas City, having an arched upper chord. Its length over all is $378'\cdot3''$, its extreme length over both long sides is $384'\cdot11''$. The difference in skew for this span as well as for the fixed spans is $6'\cdot6\frac{3}{4}''$. The depth of truss at end posts is twenty-seven feet, corresponding with the fixed spans, and at the centre is thirty-five feet, giving a versed sine of 8 feet. The posts are of the same pattern as on fixed spans. The top and bottom chords are made of channel and I beams, 9″ deep, with a top plate rivetted to their upper flanges and cross bracing pieces on the under side of chord; the chords are made continuous, being securely rivetted together with side plates. The ties are round in section, with both ends upset for screws. The four centre angle blocks are forged, the remainder are of cast iron. The turn-table has an external drum, 30 feet in diameter, made of wrought iron rolled plates, well rivetted together. Under the drum are the

poney wheels, resting on cast iron track segments, and serving to keep the truss steady when opening. There are two levers for turning the draw by hand, but, for greater ease in turning so large a mass and having more perfect control of it, a steam engine is provided, placed under the roadway and attached to the drum. The centre part around the cone weighs nine tons and is of cast iron; it is suspended on one of Sellers & Co.'s, Philadelphia, patent pivots by 12 three-inch adjusting screws. A latch, secured to the end floor beams of the truss, holds the draw in place; these latches, together with the wedges under end posts, are worked from the centre with levers. Eight hydraulic rams, each 4 inches in diameter, placed within the end floor beams, anl having pipes connecting them with the engine at the turn-table, and driven by steam, are used to raise the trusses when swung into position well above the wall plates on the rest piers, and to enable the wedges to be thrust well under the end posts, so as to prevent any distortion of the truss when one arm only is loaded, and to relieve all strain at centre on upper chord. They raise end of draw about $\frac{5}{8}$ of an inch, and have given very satisfactory results, working steadily and surely. The spring of the safety valve is rated to lift at 2500 lbs. pressure per square inch.

Erection of Superstructure.—The first pier having been completed on the 5th of July, 1870, the falseworks for this span were put in during the month, and it was swung off its bearings on the 6th of August. Although the four adjoining piers were raised well in advance of the superstructure, yet it was not allowed to be raised until a temporary trestle approach had been built for the Ferry Company, so that they could land their boats below the bridge. This caused a delay of about two weeks of very valuable time, during a low stage of water. Matters having been thus satisfactorily arranged, the superstructure was proceeded with, and the remaining seven short spans were raised before the ice formed. As the work had now reached that portion of the river where falseworks would be exposed to danger from passing rafts and steamboats, it was decided to put in cribs filled with stone and place a strong boom above, but resting against them, to fend off the rafts, and during the running ice to protect the falseworks in a measure from its shock. Whilst raising the long span, in the middle of December, the weather became intensely cold, the thermometer remaining at or near zero for several days, and the heavily running ice threatened to carry everything before it; but the patient endurance of the cold and wind by the men overcame all ob-

stacles, and the span was got out of danger in good time. The river gorged on Christmas Day, and as soon as the ice became safe the removal of this falsework to the remaining long span was commenced. This was a very tedious operation, as they had to be taken apart and the legs cut loose from the ice, and when put together again fresh holes had to be cut through the ice to get them into place. Seven of these bents had been raised in the last span when the January thaw rendered the ice very unsafe for crossing heavily loaded teams. The ferry-boat forced a channel, below the bridge, to the Illinois landing, on the 10th of January. The heavy pressure of the gorges that had recently formed on the rapids closed this channel the same evening, taking out all the bents, booms and cribs; the following afternoon the pressure became so great that a channel was forced through along the west shore, and all the ice from above moved out, at the same time throwing down seven bents of the lower falsework raised for the draw span. Although the damage was great, and lumber of proper lengths not to be procured nearer than Chicago, yet, having an open river, it was determined to push the work: but, inside of 24 hours, on the 12th of January, the thermometer fell 64°, and on the 14th and 15th, after a very severe storm of hail, sleet and snow, the river gorged again, and crossing on foot was resumed by the 19th. The uncertain state of the weather during the remainder of January and February rendered the ice very uncertain for raising the falseworks for the last span; but, as the draw span was protected with an ice-breaker pier rest, the work was resumed with an increased force and pushed vigorously, although under serious disadvantages. After a warm period, the ice finally took its departure in a very quiet manner early on the 25th of February, having been closed nearly two months. This break up was general all the way up the river, and was followed by a high stage of water, together with a large amount of heavily running ice, lasting to the 2d of March. The falseworks for the last span were commenced, in 25 feet of water, on the 6th of March. As the greater length of the trestles was under water, and the velocity of the current equal to about six miles per hour, it became a difficult matter to place these trestles and to hold them in place. By loading the bottom of the trestle legs with railroad iron the difficulty was finally overcome. The iron work was commenced at noon of the 20th and the span swung off its bearings at noon of the 24th, just five hours before the whole of this falsework was carried away by a raft that was totally wrecked by striking on one of the piers in such a manner as to

be thrown against the falsework. Although the shock to the span was very great, yet no damage to the iron work could be perceived, but it afforded one more convincing proof of the advantage of a wrought iron upper chord over a cast iron one, for the latter would have most certainly failed under the great cross strain that was brought upon it by the forcing out of the falsework.

The draw span was swung for the first time during the afternoon of the 29th of March, and everything found to come together in the most satisfactory manner.

The first locomotive crossed the bridge from the west side on the 11th of April, although one had been out from the eastern end on the 1st of April as far as the first long span, and the bridge was ready for railway traffic on the 15th of April.

A formal test of the bridge was made on the 18th of May, by Mr. Henry Petit, C. E., acting as Inspecting Engineer for Mr. J. Edgar Thompson, President of the Pennsylvania Railroad Company. For the results of these tests the reader is referred to this Journal, Vol. LXII, page 47, (July, 1871,) where they are given in detail.

Quantities Contained in the Substructure.

47,000 cubic yards of embankment in approaches.
4,500 " dry slope wall "
4,700 square yards of McAdamizing "
9,096 cubic yards of masonry in piers, abutments, and viaduct approach.
60 tons of iron in piers, pier rests and protection to pivot pier.
700 M ft. oak and pine lumber in permanent works.
300 M ft. pine lumber in temporary works.
2,900 cubic yards of crib-filling.

Quantities Contained in the Superstructure.

1174 tons wrought iron in fixed spans.
348 " cast " "
410 " in draw span.
———
1932 tons.

290,000 ft. oak lumber in flooring, } Permanent works.
153,250 ft. pine " in stringers, }
125,000 ft. " " in falseworks in erection of spans.

Total time in laying masonry, 350 days.

Total time of constructing masonry, 18 months.
Average cost of masonry, per cubic yard, was $16.
" " ten piers, complete, was $8,400.
" time of constructing a pier was 15 days.
Total contract price, $800,000.

ON THE FLOW OF WATER IN RIVERS AND CANALS.

By J. Farrand Henry, Ph. B.

(Continued from page 113.)

Such being the state of the science, it is not strange that the new theories of the flow of water in rivers, and the new formulæ deduced by Humphreys and Abbot were at once accepted by the scientific world. Dr. Hagen, of Berlin, the oldest and ablest of German hydrauliciens, after speaking of the many commendatory notices of the Report on the Mississippi, says:* "Thus the new formulæ were so praised, that the former unshaken belief in Eytelwin's formula suddenly vanished, and those of Humphreys and Abbot seemed about to take its place. I was therefore even then induced to warn my co-workers against such an unconditional acceptation of them, by showing their very weak foundation." Again, after describing his own very simple formula, given above (which he compared with the Mississippi observations and found the error only one-half as great as with their own very complicated one), he says (page 20): "If they only wished to obtain an analytical formula which would best agree with their observations, there was no need of taking into account the assumed resistance of the air, nor the other members which they have introduced." Humphreys and Abbot give a table of their own, and other observations computed by the different formulæ.

The difference between the observed and the computed velocity is in some cases as much as three feet per second.

On the other hand, these very formulæ, when used for the calculation of the discharge of water through pipes, give results which agree very well with the observations.

Dr. Brewster, in his Encyclopedia, gives an example of a pipe, 4 inches in diameter and about three miles long, with a fall of 51 feet, of which the average discharge for five years had been obtained. He computed the discharge by several formulæ, and gives the results as follows:

* Bewegung des Wassers in Stromen, von G. Hagen. Berlin, 1865. Page 5.

		C. F.
Measured discharge, 5 years' average,		11·333 per m.
Calculated by Eytelwin's formula.		11·355 "
"	Girard's "	11·265 "
"	Dubuat's "	11·257 "
"	Prony's "	11·502 "
"	Young's "	11.459 "

The agreement between the observed and calculated discharge is very close, and the simpler formulæ are rather better than the more complicated. The hydraulic mean depth of a river can be measured with nearly as great accuracy as the diameter of a pipe, and therefore the error which is found when we attempt to apply these formulæ to rivers must arise from inaccuracy in the measurement of the inclination. In a pipe, the fall can be obtained with great accuracy, and probably in a canal, where the cross section is uniform, the measured would not differ much from the true slope; but in a river, where the depth and width are constantly varying, and the fastest current is changing from side to side, the water cannot be a plane or a simple curved surface, but must form a warped surface, inclining towards one side or the other; for the fall, measured on opposite sides of a given reach of river, is rarely the same. Generally in swift rivers there is a back flow near the banks. Mr. Ellet states, in regard to the slope of the Mississippi, that "*it not unfrequently happens that while the mass of the water which its channel bears is sweeping to the *south* at at a speed of four or five miles an hour, the water next the shore is running to the *north* at a speed of one or two miles an hour. It is no unusual thing to find a swift current and a corresponding fall on one shore, towards the south, and on the opposite shore a visible current and an appreciable slope towards the north."

The surface level is also constantly changing, often sufficient to entirely mask the fall in a short distance.

In a length of a thousand feet, near the mouth of the Niagara River, where the current and inclination were ordinarily down stream, this change in the water level did not take place simultaneously at the ends of the selected line, and thus made the apparent inclination as often up stream as down.

The fall, therefore, must be measured for long distances not less than one or two miles, and great care must also be taken to have the water-level stations so situated that the velocity of the current near them is the same, for the water rises with an increase of velocity. M.

* Report, page 27.

Baumgarten found that in the swiftest current in the Garonne the water was over 0·4 foot higher than near the banks.

But in this long distance there may be bends, which by increasing the friction will decrease the velocity, and there will certainly be changes in the cross section and distance of the maximum velocity from the banks. These and other causes render the accurate determination of the inclination a very delicate matter, and in some cases an impossibility.

Dr. Hagen, in speaking of the observations of Brunnings, upon which Eytelwin based his formula, says :*. "These observations are divided into certain groups, and a single inclination given for each group.

"It is noticeable that this agrees for one, and generally the first observation in each group, with that computed by Eytelwin's formula. This coincidence is so striking that we can hardly consider it accidental. * * * In fact, the falls were not measured, but computed by Dubuat's formula, and then compared with the velocity observations. Naturally, they should agree; indeed, they only disagreed because Funk computed the inclinations for each group, and not for each observation. That Eytelwin did not refer directly to Wiebeking's notes, but used Funk's computations, is proved by the fact that he copied a typographical error in Funk's work." And, after collating all the known observations when the velocity and slope were both obtained, he says of the few observations selected by Humphreys and Abbot, for comparison with their formula :† "Of these observations of Dubuat they only used two which best agree with their theory. These are the last-mentioned, and of one of these Dubuat says that, on account of the opening of the sluice, the velocity was too great. The other eight observations, which would certainly give a very different result, they rejected altogether. Besides these, nine other observations are noted in the American work, made in the Netherlands, Italy and Russia, of which detailed notes are missing."

In a supplement to the Mississippi Report, written by Gen. Abbot for the "Essayons Club" of Engineer Officers, the observations of MM. Darcy and Bazin are examined, the new formula applied to them, and the Mississippi observations computed by their formula. The arithmetical sum of the differences between the observed velocities and those computed by both formulæ are as follows:

* Bewegung des Wassers, page 4.

† Bewegung des Wassers, page 24.

TABLE XIV.

Observations.	Sums of Differences.	
	H. and A. Formula.	D. and B. Formula.
Darcy and Bazin canals	14·085	7·158
Bayous and selected European observations	3·792	8·653
Mississippi River	2·584	13·284

Thus the error of the new formula applied to Darcy and Bazin's observations is double that of their own formula, while in the Mississippi the sum of the differences of the observed and computed velocities is nearly six times as much by the latter as by the former.

In Table XV the observed and computed velocities of the Mississippi are given, that we may examine them in detail.

TABLE XV.

Tabular Numbers.	Cross Section.		Inclination	Mean Velocity.			Discrepancy.	
	Area in sq. feet.	Mean Radius		Observed	D. and B. Formula.	H. and A. Formula.	D. and B. Formula	H. and A. Formula.
		Ft.						
1	193·968	72·0	0·0000205	5·929	4·047	5·891	+1·882	+0·038
2	195 349	72·4	0·0000171	5·887	3·710	5·641	+2·177	+0·243
3	180·968	73 6	0·0000034	4 034	1·671	3·775	+2·363	+0·259
4	183·663	74·4	0·0000038	3·977	1·781	3·911	+2·196	+0·066
5	148·042	65·9	0·0000680	6·957	7·044	7·766	—0 087	—0·809
6	178·137	64·1	0·0000638	6·949	6·710	7·409	+0·239	—0·460
7	179·502	64·5	0·0000436	6 825	5·570	6·754	+1·255	+0·071
8	78·828	31·2	0·0000223	3·523	2·681	3·920	+0·842	—0·397
9	134·942	52·1	0·0000303	3·558	4·140	5·515	+1·418	+0·043
10	150·354	57·4	0·0000481	6·319	5·495	6·517	+0·824	—0·198

Noticing, first, the relation of the inclination to the velocity in Nos. 1 and 2, the slope is 205 and 171—omitting the cyphers,—with a velocity of nearly six feet per second; while in 3 and 4 it is only 34 and 38, or one-fifth or sixth of the former, the velocity being about four feet per second, or two-thirds of the former, with nearly the same cross section. Again, in No. 6 the inclination is 638, with a velocity of about seven feet per second; while in 7 the velocity is nearly the same, but the inclination is only about two-thirds that of No. 6, the cross sections being nearly equal.

We also see that the D. and B. formula gives the velocity of that great river correctly when it is 7 feet per second, while at from 4 to 6 feet per second it gives less than half the observed velocity. There

must be some error in these measurements, or the velocity of the water in the Mississippi is dependent upon something besides the fall.

The H. and A. formula agrees, of course, with these observations, as it was based on them. These inclinations were measured by the civil assistants, one of them being re-run five times, and their disagreement is another proof of the small dependence we can place upon the measurement of the fall of a river.

In fact, with the exception of the experimental canals and small streams, there seem to be few if any inclinations recorded which are really trustworthy.

The fall of nine miles of the St. Clair River was very carefully measured, two lines of levels being run on each side of the river, and the surface level obtained at five places on each side. These points were chosen where the velocity was nearly the same, and stakes were simultaneously driven to the water surface, and afterwards connected with the marks on the level lines. There was but little difference between the two determinations, and the mean inclinations are given in Table XVI.

TABLE XVI.

Stations.	American Side.			Canadian Side.		
	Distance.	Fall.	Inclination	Distance.	Fall.	Inclination
	Ft.	Ft.		Ft.	Ft.	
A to B...	9993·5	0·7410	0·00007414	10226·5	0·7253	0·00007692
B to C...	12511·7	0·9805	0·00007839	11867·2	0·6725	0·00005667
C to D...	9695·5	0·8715	0·00008990	11534·0	0·8402	0·00007283
D to E...	17530·7	0·8805	0·00005623	14072·0	0·1775	0·00008369

The stations are lettered the same on both sides of the river, A being below the city of St. Clair, and E near Marysville, and were as nearly opposite each other as suitable places for them could be found.

Between the extreme stations the river runs almost in a straight line, and there are no obstructions except an island between D and E and a shoal opposite St. Clair. Yet the table shows great differences in the slopes, not only between the stations, but also between the opposite sides of the river. For about a mile above the station A, the river remains at nearly the same width and depth; then it widens until it is nearly twice as broad, near the town of St. Clair. Therefore it would seem as if the slope for this whole distance ought to be

rather less than that near station A, where current measurements were made.

But the measured inclination introduced into the mean velocity formulæ gives much too large a result, as will be seen in Table XVII, where the mean velocity is calculated by the different formulæ heretofore given, the smallest inclination, or that on the Canadian side, being used.

TABLE XVII.

Mean Velocity of the St. Clair River, feet per second.

A = 66147 ft. R = 38·06 ft. I = 0·00007092.

Observed.	Calculated by Formulæ.						
	Chezy Co-eff. 80.	Dubuat.	Young.	Eytelwin	Darcy and Bazin.	Hagen	Humphrey and Abbot.
3·272	4·156	4·272	4·490	4·723	5·359	5·510	5·858

Although there is considerable difference in the velocities as computed by the several formulæ, the least value is nearly a foot in a second greater than the observed velocity; therefore the measured inclination must be much larger than its true value at station A, instead of being smaller, as the increase in the cross section near station B ought to make it.

The slope for the whole distance is just about the same as that between stations A and B, except that the larger inclination is on the Canadian side, being 0·000071 there and 0·000070 on the American. As there is scarcely any change in direction in the river, the correction for bends must be very small; and the only apparent cause for a decrease in the velocity below that due to the slope, is the diversion of the current by the island between D and E and the shoal opposite the town of St. Clair.

If the true fall in such a reach of river cannot be measured, every possible care being taken to prevent error, it must certainly be impossible to obtain the inclination of ordinary rivers whose cross section and direction is constantly changing. Therefore, until some better method for the dermination of the fall is discovered, we shall apparently have to be content with the measured velocity, and not attempt to calculate it from the inclination. Surely the velocity determined from a few surface floats could not possibly differ so much from the

true mean velocity as that computed by the best of the preceding formulæ. But, as will hereafter be shown, by means of the telegraphic meter, a very near approximation to the mean velocity can be readily obtained by a few observations.

Among the formulæ given by Humphreys and Abbot is what they call the "mid-depth formula," which, if correct, would be very useful. It is as follows: $v_1 = V_1 - \frac{1}{12} (b\ v)^{\frac{1}{2}}$ in which

v_1 = the mean velocity in any division,

V_1 = the mid-depth velocity,

v = the mean velocity of the whole river,

$$b = \frac{1{\cdot}69}{(D + 1{\cdot}5)^{\frac{1}{2}}}$$

D = the depth of the river in each division,

a = the area of each division.

The mid-depth velocities were chosen because the ratio of the velocity at that depth to the mean velocity "is independent of the width and depth of the stream—except for their almost inappreciable effect upon b_1—absolutely independent of the depth of the axis, and from the small numerical value of $\frac{1}{12} b^{\frac{1}{2}}$ nearly independent of the mean velocity."

In order to test this formula, the mid-depth velocity in each division of the several rivers where not directly observed was taken from vertical velocity curves, and the mean depth of each division from the cross section profiles. These quantities for the St. Clair River are given in

TABLE XVIII.

Number of Divisions.	D Mean Depth in Division.	V_1 Mid Depth Velocities.	b $\frac{1{\cdot}69}{(D + 1{\cdot}5)^{\frac{1}{2}}}$	a Partial Areas.	$V_1 \times a.$	$\frac{1}{12} b^{\frac{1}{2}}.$	$\frac{1}{12} b^{\frac{1}{2}} \times a.$
	Ft.						
1a	15·68	1·420	0·4077	1568	2226.5	0·053	84·67
1b	29·04	3·050	0·3058	2904	8857 2	0·046	133·58
2	39·65	3·820	0·2636	7930	30355·5	0·043	340·99
3	43 55	3·975	0·2506	8710	34622·3	0·042	405·82
4	50 03	3·800	0·2348	10060	38228·0	0·040	402·40
5	52·25	3·750	0·2305	10450	38383·8	0·040	418·00
6	47·65	3·417	0·2409	9510	32495·7	0·041	389·91
7	40·77	2·880	0·2509	8155	23486·4	0·042	350·67
8	28 20	2·316	0·3155	5640	13062·3	0·047	265 08
9	15·25	1·118	0·4129	1220	1364 0	0 054	65·00
				66147	223081·7		2856·12

The value of *b* was found to be 0·1856 for the Mississippi, and it was considered that this value would generally be applicable to all streams over twelve feet in depth; but this table shows its value calculated by the formula is always greater.

In fact, in one of the divisions in another river it was over 0·7. Multiplying the sum of the partial areas by *v*, we have 661470 + $2856{\cdot}12\ V^{\frac{1}{2}} = 223081{\cdot}7$; therefore v = 3·294.

In all the observations on these rivers the mean velocity was found at about six-tenths the depth, a fact which has been noticed by many engineers, and Dupuit theoretically placed it at 0·58 depth.

The velocity at six-tenths the depth and the partial areas for the St. Clair are given in

TABLE XIX.

Number of Division.	Velocity at 0·6 Depth.	Area of each Division.	Velocity at 0·6 Depth into Area.
1a	1·390	1568	2179
1b	2·950	2904	8567
2	3·700	7930	29341
3	3·820	8710	33272
4	3·645	10060	36669
5	3·620	10450	37829
6	3·250	9510	30908
7	2·700	8155	22018
8	2·240	5640	12633
9	1·110	1220	1354
Sums.....		66·147	214770

Dividing the sum of the last column by that of the last but one, we have v = 3·247.

The mean observed velocity was 3·272; obtained by the mid-depth formula 3·294.

Thus the velocity at six-tenths the depth is a little nearer the observed velocity than that calculated by the mid-depth formula.

Probably had the velocities been taken at 0·58 of the depth it would have been still nearer. This, of course, greatly simplifies the calculation, the correction $\frac{1}{12}\,(b\ v)^{\frac{1}{2}}$ only serving to reduce the mid-depth velocities to about six-tenths the depth.

Therefore this is a still easier method for measuring the discharge of a stream, as it is only necessary to obtain the velocities at several points at six-tenths the depth, and multiply the mean by the area of cross section.

We have seen, by Table XII, that the two straight lines intersecting at six-tenths the depth approximate closely to the observed velocities; if, then, the velocities are measured at three points on the swiftest vertical, namely, at the maximum, at six-tenths the depth, and as near as possible to the bottom, and plotted on a large scale, joining these points by straight lines, we can find the velocity at any desired position on this vertical—very nearly.

MM. Darcy and Bazin and Capt. Boileau have shown that lines drawn through equal velocities assume very nearly the form of the beds, and this was also found to be the case in the observations on the rivers connecting the Great Lakes; therefore, if we draw lines parallel to the bottom and sides through any chosen velocities on the measured vertical, their intersections with any other assumed verticals will give the velocities at the points of crossing, and thus a close approximation to the true velocity of the river can be obtained by only three measurements.

Of course such observations require some such apparatus as the telegraphic meter, for by this the mean velocity for at least half an hour could be obtained at each of the required points.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. Richards, M. E.

(Continued from Vol. LXIII. page 24).

As the ruling form in metal work is cylindrical, so we find it in wood work to be rectangular.

In metal work, at least, so far as machine construction goes, the cylindrical form is a sequence of motion, which, being as a rule, rotary, leads to cylindrical sections.

In modern practice the use of wood is confined to what we will term stationary construction. We sometimes see an old-time wooden shaft, or train of wooden gearing in grinding mills; but its time, as a material for the moving parts of machinery, has passed away.

The main reason, however, for what we have termed the ruling form of section, is more due to the nature of the material than to the special uses to which it is applied.

Iron is nearly homogeneous and can be disposed in varied forms, retaining its strength independent of lamination or fibre; while on

the contrary, wood has but little cohesive strength except parallel to its fibre, and we find it in nearly all cases formed in right lines with uniform section, which is, as a rule, rectangular.

There is perhaps no exception to this rule, unless in cases of ornamentation.

Rectangular sections are surrounded by planes, consequently planing is the leading operation in wood conversion, as turning is in metal finishing.

A turning lathe performs nearly all the functions of machine fitting, or is at least capable of it, for the reason that most of the operations are cylindrical; so the planing machine in wood work performs most of the operations in wood work, because the sections are rectangular, and the surfaces planes. This logical method of accounting for what we find already developed in mechanics leads to important improvements, and should indeed qualify every experiment or change that is made or suggested; for their are certain recognized principles of movement, laws of proportion and conditions of operation in machines, which must never be neglected nor lost sight of; their application in special cases is reached by a train of reasoning which we can safely term logical, and if this logic of mechanics was more considered, progress would be more rapid, or at least more safe from error.

The planing machine has been noted as the leading one in wood conversion.

Planing in wood cutting is divided into three classes; in other words, the nature of the operation can be so divided:

Carriage planing—in which the timber is made straight, as well as parallel; parallel planing—by which the lumber is made parallel but not straight, and surface planing—by which there is a constant amount cut away from one or more sides, gauged from the surface of the wood. A proper classification of planing machines would therefore be, carriage, parallel, and surfacing planers, distinctions and names which we trust will be adopted to distinguish them, for the operation of planing wood is, in a popular way, too often regarded as the same thing in all cases, and it is frequently difficult to explain to purchasers of machines this difference of functions and difference of capacity.

The machine illustrated in Plate XI is a carriage planing machine with traversing cutter, the plane of rotation being parallel to the face of the lumber.

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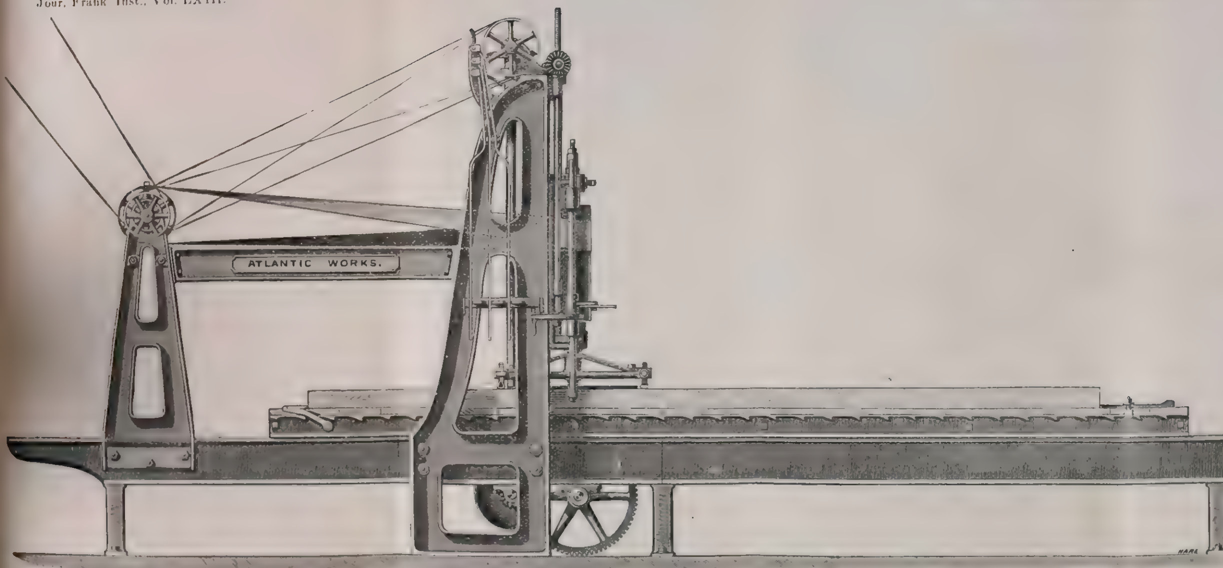

CARRIAGE PLANING MACHINE.—Scale [illegible] inch = 1 foot.

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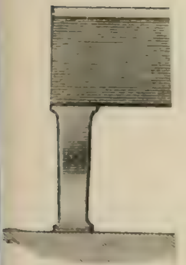
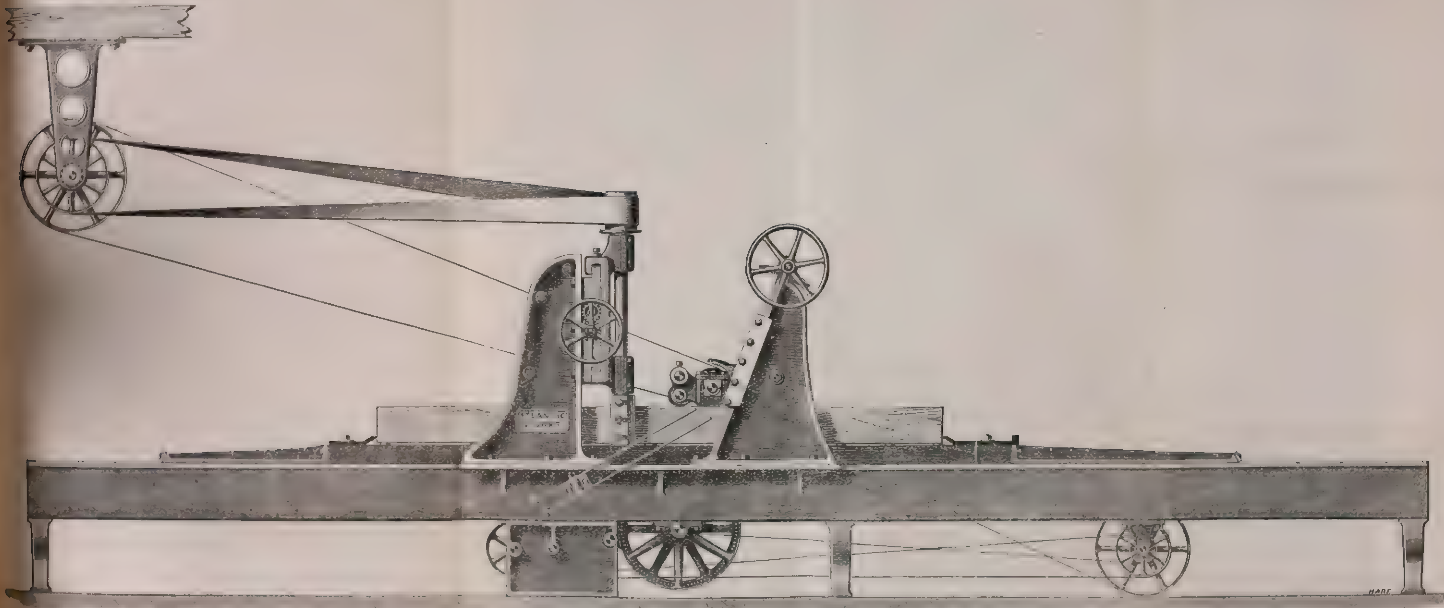




CARRIAGE PLANING MACHINE—Scale ¾ inch = 1 foot.

The machine is wholly of metal and self contained, has the variable degrees of feed motion, controlled by the hand levers seen in front. The carriage is of wrought-iron with a thin facing of wood on top. The cutter bar is of wrought-iron, spindle and shafts of steel. The cutter head and spindle are supported on a bearing that approximates the "Schiele" curve. The machine was arranged for the U. S. Navy Department, and is now being built by Richards, London & Kelly, of this city. The weight is five tons.

The amount of cutting edge that can be brought to act in a given time is, as a rule, the exponent of a wood machine's capacity. The power or capacity of a man is represented in such machines by the "length of edge" multiplied into its velocity, just as the power of a horse becomes the measure of performance in a steam engine, or, to make a more familiar illustration, the length of cutting edges in such machines is as a measure of their capacity, just as the width of belts is a measure of power, the speed in both cases being an element in the computation. Machines in which the plane of rotation is parallel to the face of the lumber, as in the one illustrated in Plate XI, can only employ a length of cutting edge equal to the depth of the displacement, multiplied, of course, by the number of cutters.

Supposing the cutters to be but two in number and the displacement one-fourth of an inch deep, the work is done with a cutting edge of *one-half inoh in length.*

Hence the slow performance and rapid wear of tools in machines of this class, compared to those wherein the cutter axis is set parallel to the face of the lumber, and the length of cutting edge equals the width of stuff multiplied by the number of cutters.

Plate XII is a carriage machine by the same builders, carrying in the aggregate *seven and one-half feet* of cutting edge, capable of moving at a velocity of eight thousand feet per minute.

The cutter spindles are so arranged that two or three sides of the lumber is dressed at one operation. The functions in general being the same as the traversing machine (Plate XI) except as to the cutting agents. The weight is about six tons. The carriage and framing is of cast-iron.

It is curious to trace in the history of wood machines, how constant and unvariable has this rule of their efficiency been as the amount of cutting edge. The planing machine, which of all others uses the most edge, will do the work of 50 to 100 men, while machines for boring, dovetailing, &c., that employ but little edge, gain but little

over hand manipulation. This subject will, however, be resumed in another article, in which hand and machine performances will be contrasted.

STEAM BOILER EXPLOSIONS.

Account of Experiments with Locomotive Engines. By Penna. R. R. Co.

No. I.

In April, 1868, an experiment was made near Altoona, on the Pennsylvania railroad, with locomotive engine No. 101. This engine was built in 1854 by Smith & Perkins, at Alexandria, Virginia; it had a copper fire-box, a grate 57 inches long by 42 inches wide, a combustion chamber 25 inches long and a straight boiler 49 inches diameter, 21 feet 10 inches in extreme length. It had been, on account of its extreme age, condemned to be cut up and rebuilt, but it was thought that something useful in regard to boiler explosions might be learned by experimenting with it, and it was determined to test the question whether low water in a boiler under high steam pressure, and the sudden injection of cold water while the boiler is heated, is or is not the cause of an explosion.

This it was proposed to do by permitting the water, under the influence of an active fire, to get so low as to uncover the crown sheet and allow it to become red hot, and then see what the result of pumping cold water into the boiler would be.

To test this, the engine in question was taken on to a branch road running to a coal mine, in a gorge of the mountain near Kittanning Point. A Richardson safety valve was placed upon the boiler, set, as it was supposed, at 150 pounds pressure to the square inch; a steam fire engine was placed about 1000 feet from the locomotive and connected with it by means of ordinary fire-hose. An extra gauge cock was placed at the level of the top of the crown sheet; a large fire was built in the fire-box, but at 110 lbs. pressure the Richardson valve commenced to blow off steam, showing that it had not been properly adjusted; it was screwed down, but as the result showed, a little too far.

The blow-off cock was then opened, and the water let down to within one inch of the top of the crown sheet, the gauge cock on the level of the crown sheet was opened, the fire-box was closed and the blower turned on. The observers then left the engine and took positions behind trees eighty yards from it, whence, by means of

opera glasses, the pressure and water gauges could be noted, and everything that took place could be seen perfectly.

The steam pressure ran up very rapidly, and it was soon discovered that the safety valve had not been set at the proper pressure, as it did not blow off. In a little over one minute after the last man left the engine, the boiler exploded at 175 lbs. pressure. At the moment of the explosion the crown sheet was covered, for water could plainly be seen coming out of the extra gauge cock before referred to, which had been left open.

The engine was thrown over a bank a distance of some 90 feet from where it had stood; the boiler and outside shell of the fire box were uninjured; the explosion was caused by the left hand side sheet of the fire-box doubling down, and tearing itself away from the stay bolts; the crown sheet being deprived of its support on that side, the bolts by which it was stayed to the roof gave way, and it hinged down, so to speak, and rested against the opposite side sheet.

The side sheets were of copper five-sixteenths of an inch thick, the crown sheet was uninjured. The mistake in the setting of the safety valve prevented the completion of the experiment which it was intended to make, namely, to pump cold water into a boiler in which the crown sheet was uncovered and heated red hot, but by the result the fact would seem to have been demonstrated that no more mysterious agency is required to explode a locomotive boiler than bad construction, or excessive pressure or both combined.

No. 2.

October 7th, 1868. An experiment was made with locomotive engine No. 17, near Kittanning Point, to try the effect of pumping cold water into a boiler with a red hot crown sheet. The safety valve was set at 120 lbs., and the engine was fired up at 8 o'clock A. M.; at 10 o'clock there was a pressure of 40 lbs. per square inch; the blower was then opened, and at 90 lbs. pressure water came out of the gauge cock one inch above the level of the crown sheet. The observers then left the engine and took positions in a place of safety, and with opera glasses watched for the result. In about twenty minutes steam issued from the gauge cock mentioned above; it and another cock two inches below the crown sheet having been left open; but in a short time it ceased coming from the upper cock which probably became stopped up.

In about half an hour more, dry steam issued from the gauge cock two inches below the crown sheet, and then cold water was pumped

into the boiler by a steam fire engine; immediately steam issued from the upper gauge cock which had been supposed to be stopped, the pumping was continued until water came from both the gauge cocks referred to, and was then stopped.

The boiler was then examined and found to have received no apparent injury. The fire was made up again and the observers again sought a place of safety. Steam soon commenced blowing off at the safety valve and blew off continuously for about fifteen minutes, and then blew off intermittently. Steam came out of the lower gauge cock and blue steam from the safety valve; in about fifteen minutes more, it being evident that the crown sheet must be very hot, water was again pumped into the boiler, the result being that the pressure was at once reduced, and on examination the stay bolts were found to be leaking, and the crown sheet was burned and slightly bulged. The temperature of the water which was pumped in was about 60°.

The Manufactures of Philadelphia.—The recent corrected report of the Census Committee contains information upon the subject of the manufactures of this city, which is of national more than of local interest, inasmuch as it presents the vast industrial wealth of the chief manufacturing city of this country in such a form that its true magnitude may be patent to all.

From these statistics, which have been introduced into the national census report, it appears that the whole number of manufacturing establishments in the city of Philadelphia, for the year ending June, 1870, was 8,339. The amount of capital employed was $185,000,357. The number of men employed, 92,112; of women, 38,478; of youths under sixteen, 10,286; wages, $61,948,874. The value of materials operated on was $181,261,223; and that of the finished products, $334,852,458. If to this last figure is added the productions of a number of manufacturing towns in the vicinity of Philadelphia, dependent upon this city for capital and labor, the sum total of the manufactured products for the year foots up $362,484,698; a sum which the Committee observe is over fifty millions of dollars greater than the entire import trade of our commercial metropolis, and one hundred millions greater than its entire export trade.

Chemistry, Physics, Technology, etc.

ON THE PRINCIPLES OF GUN CONSTRUCTION.*

By Lieut. C. E. Dutton,
U. S. Ordinance Corps.

In the first lecture were discussed the principles involved in the construction of projectiles, and the work to be done by them; in the second, the moving agent, gunpowder, was treated of. Let us now proceed to examine cursorily the difficulties to be overcome by a gun in controlling this agent. We may consider the gun as a hollow cylinder, exposed to the action of an elastic force in the bore. If the metal of which it is made was perfectly rigid, *i. e.*, if it were not susceptible of expanding under tension, or contracting under compression, the problem would be very easy, for in that case the strength of the cylinder would, if perfectly homogeneous, be directly proportional to the thickness of the walls; for the rigidity (being supposed to be absolutely perfect) would bring into play the cohesion of every part equally throughout the walls, and consequently the thicker they were, in just that proportion would they resist. But in reality no metal is perfectly rigid, and all gun metals have two kinds of elasticity. If they are subject to tension, within certain limits, they stretch; and when the tension is released, they come back sensibly to their original dimensions. If, also, they are subject to compression, they diminish in the direction of the pressure, but restore themselves when the pressure is removed. Let us see how these elasticities operate in the hollow cylinder. Conceive this cylinder to consist of a great number of concentric cylinders of small thickness. It is the inside cylinder which receives the outward stress of the forces, and it tends to stretch in the direction of its circumference, and to become thinner in the direction of its radius, being pressed between the gases on the inside and the next ring on the outside. The result is that it increases its diameter and diminishes its thickness. Let us, for the moment, drop the elasticity with respect to compression, and consider by itself the extensibility. We see the first action of the inner ring is to expand. By so doing it will communicate an outward

* The following paper is one of a course of lectures delivered before the Franklin Institute at Philadelphia, in January and February, 1872. Revised for publication.

pressure to the next ring, which will also expand, pressing outward the third, and so on to the last. Suppose, at first, that the metal is extensible but incompressible, all the rings would then be stretched, and their diameters and circumferences increased. They would all be increased too by an equal amount. But the interior circles are smaller than the exterior ones at the outset, and though the circles have all stretched the same amount *absolutely*, yet the interior ones have stretched more *proportionally*. Assume, if you please, that the diagram represents a cylinder with a calibre of one foot, and with walls a foot thick. Then the outer circle is three times the circumference of the inner. Suppose the inner circle has been stretched a tenth of an inch; if the metal does not compress, then the outer circle has stretched a tenth of an inch also. But it is clear that a tenth of an inch is a larger proportion of the circumference of the inner circle than it is of the outer one; and in fact the stretch of the inner circle is three times as great, per lineal foot, as that of the outer. Hence, when the inner circle had reached its elastic limit, the outer circle would be only one-third of the way to that point. Now the amount of stretch measures pretty nearly the amount of strain, and the amount of strain measures in turn the amount of *re*-strain, which any circle exercises. As the outer circle is three times as far from the common centre as the inner, and its restraining influence is only one-third as great, we conclude that the restraining influence of this ring is inversely as its distance from the centre, when the metal is incompressible.

Let us now introduce the effect of compressibility. In the first supposition, the expansion of the inner ring pushed out all the rings outside of it, increasing their diameters exactly as much as it did its own. But if the rings had been made each a very little thinner at the same time, it is clear that the increase of diameter would be less and less in each succeeding circle from the inner one outwards. Hence, the amount of stretch in the outer rings is still further diminished by the introduction of this second elasticity, which tends, just as the other one did, to diminish the restraining influence of the outer circles. The effect of this is to bring the inner portion of the wall of the cylinder up to the point of rupture before the outer portions have exerted more than a small part of their real strength, and when rupture takes place it does so in detail—the inner part breaking first, while the outer parts are barely exerting themselves. To follow out the law by which the restraint of different portions of the wall is ex-

ercised is a profound application of the higher calculus, which has no place in a lecture.

It is sufficient for us to know that, in the strength of a gun, the restraint of the outer parts becomes very rapidly less as the diameter of the exterior increases, and that we add little to the strength of a gun by increasing its thickness beyond a certain point. But although we may not here enter into an analysis of the ratios of these properties, we may give them a general discussion, which will present them in a tolerably appreciable manner.

The properties of metals for guns, which are of importance, are quite numerous. Inexperienced, or I may say, inexpert thinkers on this subject are in the habit of paying attention to a single property, viz., tenacity. It is a common impression that what are usually termed "strong" metals can alone be recommended for this purpose. When we come to sift the meaning of the term "strong" we find that it means tenacious, and the standard of tenacity is established by taking a short specimen of it, putting it into a testing machine, and pulling it asunder with a measured force. I propose to discuss this property further on, and will merely say here that, other things being equal, a highly tenacious metal is better than a less tenacious one. But the discussion just given of the hollow cylinder makes it evident, I trust, that other properties are equally important. Let us enumerate some of them :

1. *The tenacity within the elastic limit.*—It is necessary to distinguish clearly between the power to endure extension, and resume the original shape afterwards, and the ultimate stress which a metal can endure. It is generally held in gunnery, that if the stress be greater than the limit of resilience the rapid degradation of the gun is sure to follow, and the only value attached to the excess of tenacity lying between the limit of ultimate resilience and ultimate tenacity is to make the destruction progressive instead of immediate. Yet this is no doubt a most valuable property; for by watching the enlargement of the bore of the gun, we can form a very good idea of how much it has been degraded by firing, and how much of its endurance has been expended.

2. *Hardness.*—This quality is of great importance for two or three totally distinct reasons. The first one will be seen when we consider what has been said of the expansion of hollow cylinders by internal force. Take the case of a cylinder having a given tenacity but inferior hardness, and compare it with that of a cylinder of the

same size and the same tenacity, but harder. It is clear that the one of harder metal will, for a given amount of expansion in the inner ring, push the outer rings farther away and stretch them more, thus bringing the strength of the outer portions more forcibly into co-operation with the inner portions. Hence the harder cylinder would be stronger than the softer, although the tenacity of the two metals might be identical. Hardness is also necessary to prevent the bruising or hammering of the projectile. A soft metal is quickly indented and the bore battered out of shape, by the balloting of the shot when spherical projectiles are used, and in case of rifle shot the sharpness of the lunds is soon worn off and the rifling destroyed. Still again, hardness is essential to prevent the guttering or channeling produced by the action of the gases of inflamed gunpowder. Soft metals are acted upon most destructively in this way, and deep channels are quickly worn in the bore and around the vent. Hard metals, too, are more or less affected in the same way, but much more slowly than soft ones.

3. *Extensibility* is the degree to which a body can be stretched; it is usually considered only so far as it lies within the limit of resilience. It appears that the metal which is most extensible (without permanent set), other things being equal, is to be preferred, since it brings the outer parts more effectively into co operation with the inner.

4. *Elasticity with respect to tension* must be clearly distinguished from the foregoing property. By elasticity is meant a certain power of resistance to the action of a force, and in this case it is measured by the ratio between the amount of stretch and the force required to produce it.

5. *The elasticity with respect to compression* is always important. By this is meant the ratio between the amount of compression and the force producing it. The metal should be as nearly incompressible as possible, for the more compressible it is the less is the strain thrown upon the exterior portions and the more upon the inner.

It appears, then, that the properties which enter into a good gun metal are numerous and complex. But complexity would give the scientific gun-maker very little trouble were the properties all as plain and intelligible as those mentioned, for the mathematician does not stop at complexities; give him the facts and the laws, and he will quickly find a solution. Unfortunately there are other qualities in-

herent in and peculiar to metals, which escape satisfactory analysis, and which sometimes show their existence in the most disastrous manner. The bursting of a gun is always a most serious matter; but, to the ordnance officer, the most formidable and deplorable circumstance connected with such mishaps is that they often occur when least expected, and from causes not understood. If we knew those causes accurately, we could very probably avail ourselves of the resources of modern metallurgy and devise a remedy; but we too often find ourselves like physicians in the midst of diseases unknown to our pathology, and merely know that our tonics are powerless. Take an instance:

A steel axle, turned with a sharp "shoulder," is almost sure to break at the smallest provocation, and nearly every mechanic may be able to recall instances where pieces of steel with shoulders have actually seemed to be shaken in two by a jar or shock which would have given no inconvenience to a piece of wrought iron or even cast iron; and every lathe hand understands well the importance of rounding the reëntrant angles of a steel forging. In explanation of this mode of breaking, it has been suggested that the differences in the pitch of vibration of the parts on either side of the shoulder causes an interference of the waves at that point. But let any man try to conceive how this can produce rupture and he will find himself as much puzzled as ever.

Still again: Some years ago an experimental boiler for one of our naval vessels was constructed of steel. During the process of riveting, a plate was found to have cracked through from top to bottom. A fragment of this plate was afterwards folded and refolded *quarto*, and the folds hammered down cold, without a sign of a crack anywhere about it.

Now, we call this peculiar behavior brittleness, and yet no man has ever explained this property, or told us how it comes about that a material which is strong in the presence of one force is miserably weak in the presence of another. No man has been able to measure it and give us such an insight into its operation that we can calculate its effects upon the resistance of the material which it inheres. There is some property similar to brittleness in gun metals, and that, too, in some gun metals which do not exhibit it sensibly in those forms and under those forces in which they usually are employed in the arts. Its operation will become clearer when we treat of the metals possessing this mysterious property.

The metals employed in gun-making may be confined for this lecture to three: (1) cast iron, (2) wrought iron, (3) steel.

I. The popular idea of cast iron is that of a weak, brittle, hard, and generally vulgar and contemptible material, very good for anvil blocks, stoves, engine bedplates, pots and kettles, and for any purpose where weight and stability are required, but out of the question when strength is demanded. I do not wonder that this is the popular idea. The iron in ordinary use is just about fit for anvil blocks, and pots and kettles, and so far as strength is concerned is as bad as human ingenuity can make it. How many iron founders in Philadelphia to-day, excepting possibly the car-wheel makers, and roll makers, and one or two kindred trades, where must be used strong iron, have ever troubled themselves to inquire whether the iron they use is strong or weak? So long as it fills the mould well and is cheap they are satisfied. The great demand is for an iron which will fill well a greensand mould and melt rapidly in a cupola. But it happens that these very properties of great fluidity, soundness and fusibility, are engendered by the presence of foreign elements, which deprive it of strength, toughness and elasticity. Take phosphorus, and silicon, and the metals aluminium, calcium, sodium—you find the largest quantities of them in those irons which make the best castings. The fame of the Berlin castings is world wide—castings which will reproduce in metal the figures of a damask napkin or point lace; the property which enables the metal to receive these imprints and retain them is due to the presence of an abnormal quantity of phosphorus, calcium and silicon, and the metal is as brittle as glass and slightly stronger than a brickbat. Scotch pig is used in the arts on the same principle as proof spirit is used in trade. Too utterly abominable to be used by itself, it is employed to "rectify" other irons, and the fluidity and soundness of castings when Scotch pig is used is due to the fact that this brand carries with it about one to three per cent. of phosphorus, and an unusual percentage of other impurities. But I wish to convey in the strongest and most emphatic manner the impression that the iron now used in the manufacture of cast iron guns is separated by a very wide interval from the cast iron of the trades. To contrast the popular idea of cast iron with the ordnance idea of it I will state that Mr. Anderson, the former Assistant Superintendent of the Royal gun factories at Woolwich, a few years ago, in a paper on the subject of gun construction, spoke of cast iron as a metal having an average tenacity of 14,000 lbs. per square inch, and applying

the ordinary factor of safety (5), said that it could be relied upon for a stress of about 3000 or 4000 lbs. per square inch. Now the standard of tenacity of our ordnance irons is between 36,000 and 40,000 lbs. per square inch, and we do not hesitate to work them up to three-fourths of their ultimate tenacity, or say 27,000 to 30,000 lbs. per square inch, which is just about eight or nine times as high as Mr. Anderson put it. We have done this practically for the last ten years, and have not burst a solitary gun, except in cases where we knew we had exceeded the ultimate possibilities of the metal.

The selection of ores is confined to those which are most easily reduced. They must also be very free from phosphorus and sulphur, and must be acted upon at a low temperature in the smelting furnace. Those hitherto in most favor are the limonites of that series to which the Salisbury, Copake, Tyrone, Sligo and Bloomfield beds belong. As these ores contain considerable alumina and silica, they require but a small addition of lime to make a very fusible flux, which admits of their being smelted in a charcoal furnace of small size, and with a cold blast. The low temperature of smelting enables these ores to reduce with only a small quantity of silicon and earthy bases, and a high percentage of carbon. The iron thus smelted is subjected to repeated fusions in an air furnace, and each successive fusion removes a considerable proportion of the silicon and carbon. The carbon is kept up by adding to each result some pigs containing the highest percentage of that element, and the final casting is made from irons containing a very low percentage of silicon and a moderate quantity of carbon, and as free from other impurities as it is possible for any cast iron to be. The resulting gun metal is chemically not far removed from steel, and its mechanical properties approach those of a sand-cast steel ingot. The only limit to this process of refinement is the possibility of keeping the metal sufficiently fluid to cast well. As cast iron parts with its impurities its fusion point is raised, and at last becomes so high that the reverbatory furnace can no longer keep it fluid, and it solidifies into a spongy mass, which is wrought iron or semi-steel. Hence, in the use of an air furnace the iron must not be refined so far as to become viscous, for it must retain sufficient fluidity to pour and cast thoroughly well, otherwise the casting will be porous and honey-combed. The metal of our cast iron guns is tenacious, very hard, elastic under tension, and very moderately so under compression, and possesses in a high degree the properties essential to a good gun metal. Its tenacity up to the limit of permanent set is much

less than that of steel, and its hardness is decidedly greater than the soft steels used for guns, while its extensibility is less. It is more incompressible than the low steels used for gun-making, and far more so than wrought iron. In a comparison of the products of these properties the theoretical advantages are in favor of steel, but not so overwhelmingly as might be thought if we judged the two by merely comparing their tenacities, for the superior hardness and incompressibility of cast iron bring into play the outer circles of the hollow cylinder more effectually than in steel; in a word, the restraining influence of the exterior portions is greater proportionally in a cast iron gun than in a steel one of the same dimensions. But on the whole, so far as strength depends upon known conditions, cast iron is inferior to steel, but not in proportion to their respective tenacities. There are some unknown conditions, which may or may not affect the case, which will be alluded to further on. Up to the limit of its strength, as determined by theory and verified by experiment, cast iron is thoroughly to be relied upon, and the long and fruitful experience of our officers with this metal leaves no doubt that every failure may be accounted for by the fact that the guns which have yielded have been overcharged.

Cast-iron appears to be suitable only for smooth-bore guns. The increased strain caused by the longer column of metal in firing elongated projectiles renders it more than doubtful whether we shall be able to avail ourselves of this metal in constructing rifled cannon, especially large cannon. Theory indicates that, even at the most moderate pressures of gunpowder, we are verging very near to the limit at which our strongest cast-iron must break, and our experience with large rifles has shown that these pressures are liable to spring up to a destructive point when we least expect it, in which case the gun must rapidly give way.

On the suitableness of wrought-iron for gun metal there has always been much controversy, and even to-day the only advocates of this metal are the English, who differ greatly among themselves on this point. It is now established by proofs of the strongest character that wrought-iron, in the form of coils, is a very superior metal, though a majority of the European gun makers and mechanics consider it much inferior to steel. I shall speak of its record elsewhere, and discuss at present its peculiar properties.

The ultimate tenacity of wrought-iron, as indicated by the ordinary tests known among us as the Kirkaldy tests, is about 50 per cent.

higher than that of our cast-iron. But it possesses a property which pertains only in a small degree to cast-iron, viz., the property of elongating very considerably and permanently under tensions below its ultimate tenacity. We call this property ductility. Although wrought-iron shows measurable and permanent elongations at strains of a few thousand pounds per square inch, it is not usual to treat of them as having any practical value until the strains amount to about 25,000 pounds, at which point the elongations begin to be serious, and increase rapidly up to the breaking limit, at which stress the elongations sometimes reach in very tough iron 20 and even 25 per cent. of the original length. Moreover, repeated applications of the load give increased elongations. In treating of the tenacity of wrought-iron, therefore, we have no right to take as a standard of its useful or working strength the limit of ultimate tenacity, but only that portion which lies within the practical ductile limit—for it will appear that a gun which stretches permanently and to a material extent after every fire will soon become practically useless by the enlargement of the bore at the seat of the charge. This very difficulty occurred in a gun made at Salisbury, Conn., out of the famous iron of that locality, which had enlarged so much after a few fires that it was virtually unserviceable. Although this form of degradation is by no means so objectionable as a liability to burst, yet it is abundantly so to condemn any material in which it cannot be avoided.

Now, if we are to take the Kirkaldy tests as the standard of tenacity, or resisting power of the metal, we should, by strict logic, confine ourselves to the ductile limit as the available and practical measure of strength, and not attempt to reason from its ultimate tenacity. But I do not hesitate to assert that the Kirkaldy tests would thus underrate the value of wrought-iron, and cannot be logically used to base upon them any inferences respecting its suitableness for gun-metal. The break in the logic which would so use them lies in the fact that the stress is applied in the testing machine cannot be compared to that applied by gunpowder. I am not questioning Mr. Kirkaldy at all, whose tests are accurately and intelligently made and reported, but am merely questioning the logic which would use them to infer the utility of wrought-iron as a gun-metal. If these tests could be so used, then we should have to set down the useful limit in the tenacity of wrought-iron at 25,000 pounds per square inch, or say about one-half its ultimate tenacity, the residual half being useful only so far as it allows the gun to bulge instead of burst. But, if

there be any result in the English experience of the last fourteen years more clear than another, it is that this useful limit of wrought-iron tenacity is very considerably higher, although it is probably not up to the ultimate limit. We may, perhaps, find a satisfactory solution of this fact. The ductility of a metal is one case of the phenomenon termed the "flow of solids. The forcing of lead pipe is a striking illustration of another case. But in the flow of solids time is an important element, for the viscosity of the material requires that the particles, whose relative positions are changed, should have time to adjust themselves to the changes induced upon them ; and the more powerful the cohesion, the more slowly do they obey the impress of external forces. Hence, when we apply the stress very suddenly and briefly, we find that we do not obtain anything like so great an elongation as when we apply it slowly, because we do not give the particles time to yield to the force and take new cohesions. But it is also probable that, while we find a higher ductile limit with sudden forces, we probably find also a lower ultimate limit of tenacity. The evidence in support of this view is not so abundant as might be desired, but is yet very strong, and I know of none to the contrary ; the subject does not seem to have been thoroughly investigated, and consequently evidence in either direction is indirect. But we may safely say that the useful limit of tenacity in wrought iron is considerably higher than the ductile limit assigned by such tests as Mr. Kirkaldy's. Comparing it with cast-iron we have, in the latter metal, no such thing as ductility, and have only the ultimate tenacity to consider. Experience with coil guns seems to warrant the conclusion that the useful tenacity of wrought-iron is a little higher than that of our best cast-iron, but there is no satisfactory proof that it is very much greater.

The foregoing remarks may have some bearing on an objection raised against the Woolwich system of construction by those who advocate the use of steel alone, viz., that after a few fires the wrought-iron coil soon ceases to exercise any restraining influence on the steel tube, being permanently stretched, while the tube is working within its elastic limit. If the useful strength of wrought-iron is as low as the Kirkaldy tests would place it, this hypothesis is not improbable ; but if, as I conceive, it be materially higher *in the gun*, its probability is greatly diminished. Yet, if we assume that there is a certain margin of ductility in wrought-iron, even in the gunpowder test, and if the limit of it be considerably lower than the elastic limit of steel, we may still look for this relaxation of the coil when the stress of firing

becomes very great. It would be more likely to occur in large guns than in small ones; but in any case the considerations advanced seem to modify greatly the force of this objection to the Woolwich system, which has certainly demonstrated the efficiency of wrought-iron as a gun-metal most satisfactorily.

We have always associated with steel the ideas of strength, endurance, hardness and homogeneity, in their perfection, and it is quite natural that the gun-maker should look to this metal as the one better suited than all others to restrain the terrible forces he is compelled to use. If we take its resistance to strains as indicated by such tests as Mr. Kirkaldy's, we shall be led to infer that the useful strength of steel is more than double that of wrought-iron, and about three times as great as that of cast-iron. Unfortunately our whole reasoning respecting this metal is based on the breakages of innumerable specimens of less than a square inch of cross-section. Treatises on the strength of materials assume that the resistances afforded by these small specimens are units, or constants, by which the strength of a mass of any size and any geometrical figure may be measured. But do facts sustain this reasoning? Do they show that a large mass of metal really possesses as much strength per unit of cross-section as a small test specimen? It may seem to be a singular question to propound at this late day, whether the whole basis upon which that branch of mechanics known as "strength of materials" rests, is really a sound one; whether all the mathematicians and mechanics who have discussed the subject have not overlooked a very obvious consideration of a vital character. But let us examine the matter a little. Is there in the whole range of experiment on the strength of metals a well authenticated instance (excepting certain ones which will be alluded to), where a large mass of wrought-iron or steel has been subjected to trial, to test empirically the question whether a large mass is really as strong per unit of cross-section as a small one? Certainly no known treatise and no adopted formula or theory recognizes any such ideas to the contrary. What are the English Admiralty tests? what kind of tests have been adopted as standard by the French *Conservatoire des Arts et Metiers?* by the Swedish, Russian and Prussian Governments? Every one of them adopts as standard units the results given by the extreme proof of specimens having a section of about a square inch, and in some cases less. From these the strength of a larger mass is always deduced by a purely theoretical formula. The only apparent qualification to this state-

ment of the case is the use of a factor of safety, which means that, in practice, a piece of metal in a large structure is not to be relied upon to give a resistance to strain in excess of one-fifth of this calculated strength. 'But is it not most extraordinary that, after an elaborate calculation, we are obliged to throw away arbitrarily four-fifths of our result as being probable error, and keep only one-fifth ? We may very properly allow something for weak spots, imperfect workmanship, &c., something also for the "fatigue" of the metal; but surely no man would think of thus disposing of four-fifths of the strength he calculates upon, had he not before him the unanswerable fact that numerous structures, in which a smaller factor of safety has been used, have collapsed.

If we take the case of a rod, subject to a simple tensile stress, it certainly seems a fair inference that ten square inches cross-section ought to withstand ten times as much as one square inch, with a small deduction for assumed lack of homogeneity. A few months ago, Mr. James B. Eads determined to test this question—for such he deemed it. In a huge machine, constructed for the purpose, he caused to be placed some long steel anchor-bolts, 5¾ inches diameter, and the first four snapped at strains averaging about 30,000 lbs. per square inch, while a number of small samples (three-quarter inch section), taken from the crop-ends of the bolts, all endured upwards of 100,000 lbs. per square inch without a single failure.* It would certainly be unwise to undertake to prove a new view of the strength of materials from a single series of experiments. But this does not fairly state the case. There are several considerations of great moment which are applicable at this juncture. First, it must be remembered, that no experiments with large masses have been made and put on record (at least, so far as is known to me), with a view to test this matter, excepting the one first alluded to. Second, many striking cases may be cited to illustrate the belief that large forgings of steel often fail to exhibit, from some unexplained cause, the strength indicated by test specimens. It would be impossible to give a clearer illustration of this than by quoting the record of solid-forged steel guns.

* Having witnessed the forging and testing of these bolts, and taking particular interest in the matter, I cannot soon forget the astonishment felt by all who saw these failures. It seemed to be quite inexplicable. Some attributed it to internal strains, and another lot of rods was annealed, but with results no better than before. Taken in connection with the extreme care and accuracy of the whole trial, the whole matter became extremely perplexing, nor is there any apparent way of explaining it without resort to conjectures not usually entertained by engineers.

LECTURES ON VENTILATION.

Delivered before the Franklin Institute.

By L. W. Leeds, Esq.

(Continued from page 216.)

We have here a diagram, prepared at the request of some gentlemen of his city,* showing some suggested modifications of the ventilation and warming of the Hall of Representatives. It is proposed to draw off the foul air both at the top and bottom.

That taken from the bottom is to be drawn through the present inlet registers, and that from the top to escape around the sides of the glass as at present, and through the illuminating loft to the external air.

Now, with a little ignorance or carelessness it would be very likely to be so arranged that discharging the air in two opposite directions might make confusion, and that it would, at times, all draw up, and the foul air, instead of escaping at the floor, would flow in there; and at other times it would escape at the floor and come in at the ceiling; but it is very easy to avoid such action and with entire certainty.

This is the proper manner to arrange all large buildings intended to be occupied by a considerable number of persons; there should be escapes for foul air thoroughly distributed over the floor, also liberal escapes from the ceiling, and these should be kept constantly open when the room is occupied, and there is no practical difficulty whatever in doing this.

It was originally intended to overflow the hall with the fresh air driven in by the fans; but, practically, this is not the general condition. Several experiments, tried at various times, indicated a strong current setting into the Hall of Representatives from the corridors through every door, both above and below, so that practically the main room is supplied by air from the surrounding passages; we consequently recognize this fact and act accordingly. Arrangements should therefore be made to keep the air in these passages as nearly pure as possible.

It is proposed to warm the floors of the hall slightly in excess of the temperature of the room, say to about 80° or 85°, which would still be below the temperature of the body; and also to have all the exterior walls warmed so that there would be a gentle radiation from all the solid bodies in the room. When we are not losing heat by con-

* Rand, Perkins & Co., of Philadelphia.

duction, from contact with a cold floor, and are receiving radiant heat from all the surrounding walls, instead of parting with the warmth of our bodies to these walls, we can afford to be surrounded with and have the luxury of fresh, cool, invigorating air for breathing.

As the corridors would be largely warmed by radiation, the air in them would be cooler than the indicated temperature; it would, consequently, flow into the hall underneath the air longer contained there.

It is not intended, however, to depend exclusively on the supply of air from the corridors in case the doors should all be intentionally or accidentally closed; there would be an abundant supply of air from portions of the perforated ceiling. In winter arrangements would be made to warm this to the required temperature, but as so considerable a portion of the warmth of the hall would be furnished by direct radiation, it would only be necessary to have this air heated to 50° or 60°; consequently, being slightly heavier, it would easily fall in gentle, well diffused currents, to take the place of the foul air drawn out both above and below.

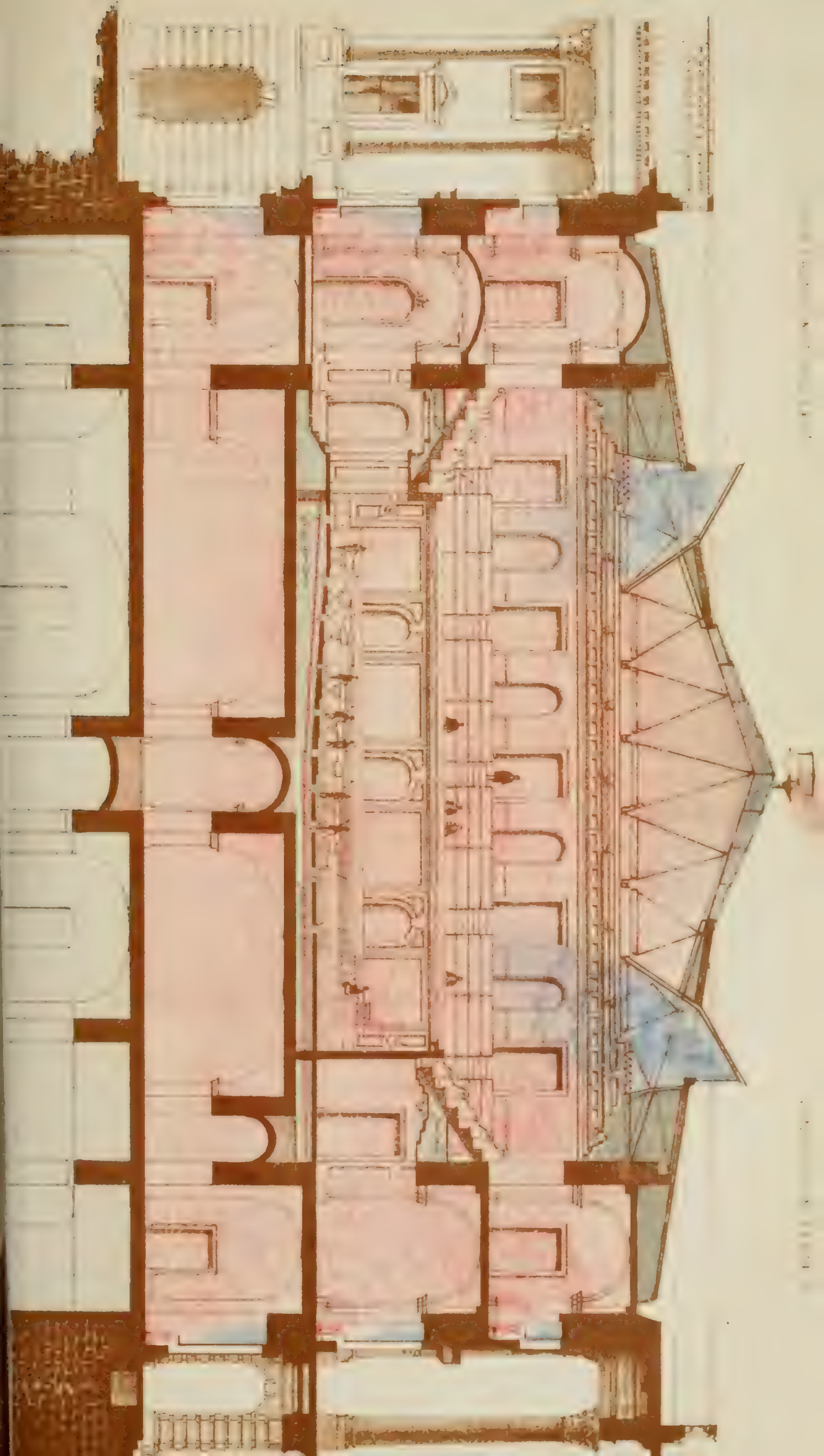
Many persons are afraid of a draught of cold air upon their heads, but if the surrounding conditions are right this is just the position to have it strike the body. For instance: I have stood on the hot plates in front of the boilers in the hold of a steamship, with my back towards the hot boilers, and had a perfect torrent of very cold air falling on the head, which felt delightful.

The firemen are constantly subjected to this without injury, but if they go on deck and stand in a draught, or cool off quickly, *away from the radiant heat*, they frequently take severe colds.

One difficulty about having a cold draught upon your head; it is very apt to be *colder* on the feet, but that part is frequently not noticed.

It is also proposed to put in a row of dormer windows, that would let in more sunlight, and perhaps some of the direct rays of the sun, and in summer would be very useful in catching the breeze as it passed and throwing it directly into the hall as you see here (refer to diagram). It is proposed to entirely disconnect the illuminating loft, so as to avoid the possibility of a returning current of foul air as now occurs; also to make an additional plastered ceiling and a confined air-space to prevent the rapid cooling effect of the exposed copper roof.

It is proposed to dispense with the fans entirely, which I consider



about the greatest nuisances in the building, and rely exclusively on heated shafts.

The same amount of heat applied to a well constructed shaft will probably move a much larger amount of air, at a great deal less cost, and requiring no expensive engineering attendance.

I believe if this plan was carried out it would make a very satisfactory building; perhaps the Hall of Representatives would not be quite equal to a single room, with the walls and floors warmed, and large windows on all four sides for the free admission of air and sunlight, but it would be so much better than many of our public halls, that by comparison it would be considered very good.

The Treasury Building, at Washington, is one of the most substantial and expensive executive buildings in the world, having cost some $5,000,000.

No expense has been spared in any part to make it the most perfect, comfortable., and convenient building that the ingenuity of man could devise.

I wish you to make a distinction here between the errors of original design and construction, and the troubles resulting from its shameful abuse, because the former show the deficiencies of correct knowledge in this respect among the best informed architects and builders; but the most shocking condition of the old building and ill health of the occupants, as I found them, result very largely from the shameful abuse of it after its completion, and show us the want of general information in the public, which will prevent the very best arrangement that could possibly be made becoming an intolerable nuisance, as was the result here.

It must be remembered that this whole block has been many years in building and reaching its present size. The plans represent it, as now finished, as a single completed building, but we must examine it in parts, according to the ages in which it was built.

The old front on Fifteenth street has been built probably fifty or seventy-five years—quite long enough, at any rate, to show in its original construction those ample old-fashioned fire-places where hickory wood, and plenty of it, was burned in each room.

And when these were in full blast an examination of the absentee list would show a much smaller proportion of excuses for sickness from foul air diseases than at present, with these fire-places carefully boarded up or walled on top, and all the rooms heated from one large central boiler in the cellar.

Most of this part of the building has been remodelled, so as to be heated by radiation from hot water coils in each room, great care having been taken to shut up all crevices to prevent any cold draughts.

The south wing and west wing have been completed much more recently—mostly within ten years. This is the portion of the building which I wish you to examine more carefully.

That cleanly and refined system of murdering human beings, which has spread like a devouring pestilence over our whole land, came into general use about the time this building was designed.

I mean that miserable system of warming our rooms by currents of over-heated, debilitating and ruined air.

At that time I myself was one of its zealous advocates. I had already noticed the universal complaints of the occupants of rooms which were heated by currents of air from the common hot air furnace, but supposed it resulted from some peculiar effect produced by the overheated iron, and consequently went energetically to work to remedy these evils by warming all the air, by bringing it in contact with metal surfaces moderately warmed by circulating hot water.

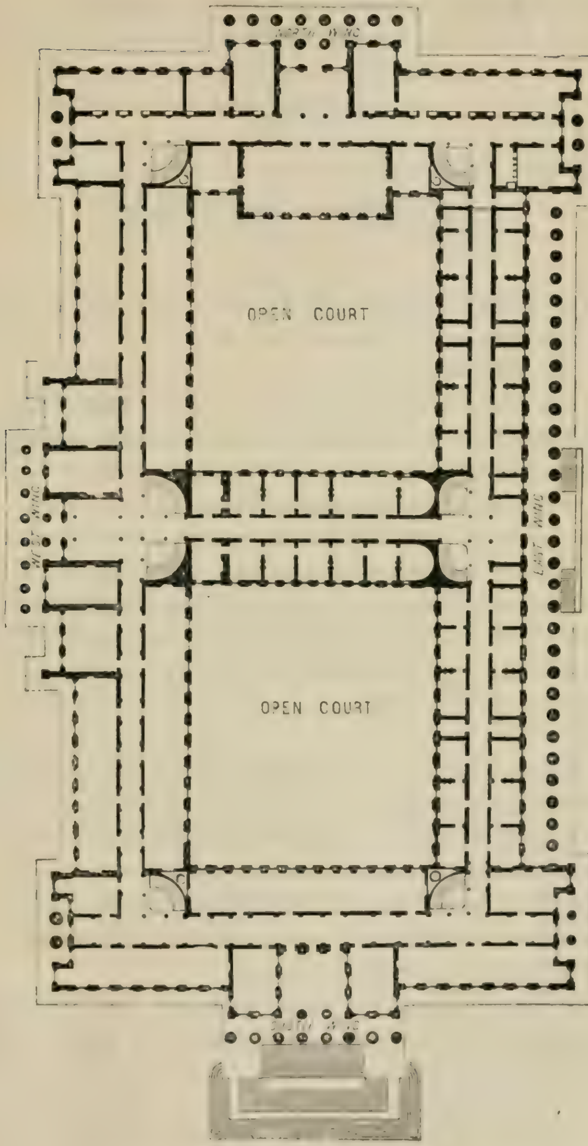
I persevered many years, inventing and patenting in this country and in Europe, new and improved devices for accomplishing this object, fully believing that a building, constantly overflowed with this mild, warm, summer-like air, must be the perfection of artificial heating.

And yet I was chagrined and mortified that many sensible people, with good independent judgment, would still insist upon it that they felt better, their heads were clearer and brighter, in a room heated by an open fire than in a room heated by my hot water apparatus.

It was thus forced upon me, little by little, year by year, that there was a very essential difference between the room heated by an open fire and one warmed by currents of heated air.

I was just going to say I *soon* learned, but I *didn't*. I *slowly* learned that all warmed air was unwholesome and debilitating; that it was not the manner of warming, but it was the fact of its being warmed; that the sun itself could not warm it so as not to produce this debilitating effect, as witnessed by the fearful mortality whenever the air in summer reaches nearly the temperature of the body.

In proportion to my convictions of the unwholesomeness of warmed air did I advocate the introduction of direct radiation—first one-quarter, then one-third and one-half, and perhaps some time I may believe in *heating* by radiation entirely. But there is one practical difficulty



about this, and that is, where the necessary air for ventilation is passed through the room, and it is quite cold, it is so difficult to avoid unpleasant draughts; it requires very careful diffusion.

There are, consequently, fewer complaints of such draughts when

all that air is warmed, especially as all the occupants are so stupefied they have not much energy left to do anything—not even to find fault.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Meeting, Nov. 25, 1871.

The meeting was called to order by the President, Mr. Coleman Sellers, at the usual hour.

The minutes of the last meeting were read and approved.

The Actuary submitted the Monthly Report of the Board of Managers, and reported that, at their stated meeting held November 8th, donations to the library were received from

The Institution of Civil Engineers—their proceedings for 1870–71. The War Department at Washington—the Practical Use of Meteorological Reports and Weather Maps. The Geological Society, of London, and Literary and Philosophical Society, of Liverpool, Eng.

The Actuary also reported that, at their last meeting, the Managers had passed the following

Resolution, That the thanks of the Board of Managers be and are hereby presented to Prof. Henry Morton, for the interest manifested in the success of the Institute, in tendering his services, without compensation, as a lecturer at the Academy of Music.

In relation to this subject, Mr. Orr moved the following:

Whereas, Prof. Henry Morton has informed the Board of Managers that he declines any pecuniary remuneration for his late lecture at the Academy of Music, therefore

Resolved, That the Institute duly appreciates the substantial kindness from its late Secretary, and offers cordial thanks for the same; and directs that a copy of this preamble and resolution be transmitted to Prof. Morton by the Secretary.

The Committee on the Horse-Power of Boilers reported progress, and was continued.

The Secretary next read his Monthly Report on Novelties in Science and the Mechanic Arts, when the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LXIII.] MAY, 1872. No. 5

EDITORIAL.

ITEMS AND NOVELTIES.

An Improved Testing Machine, *Manufactured at the Philadelphia Scale Works.*—The frontispiece of our Journal for May is a photo-plate, by Rehn & Dickes, of one of Riehle Brothers Improved Testing Machines of 40,000 pounds capacity. The frame is of seasoned oak timber, stands nine feet high, and the whole apparatus weighs about 2000 pounds. It consists of a compound parallel beam, grips for holding the test pieces, and a hydraulic jack and pump.

The beam is suspended by the upper clevis and the jack is secured to the frame below, and the proper tools and piece for testing are placed between the beam and jack, connected to the former with the lower clevis, and to the latter by a yoke.

Now the strain is applied by the jack and pump, and the weighing beam kept in equipoise by the weights and weighing apparatus, and by that means actually weighs upon the beam the strain that the test piece is being subjected to. The treadle that is below the frame is for the purpose of raising the jack after it has been forced down in applying the strain.

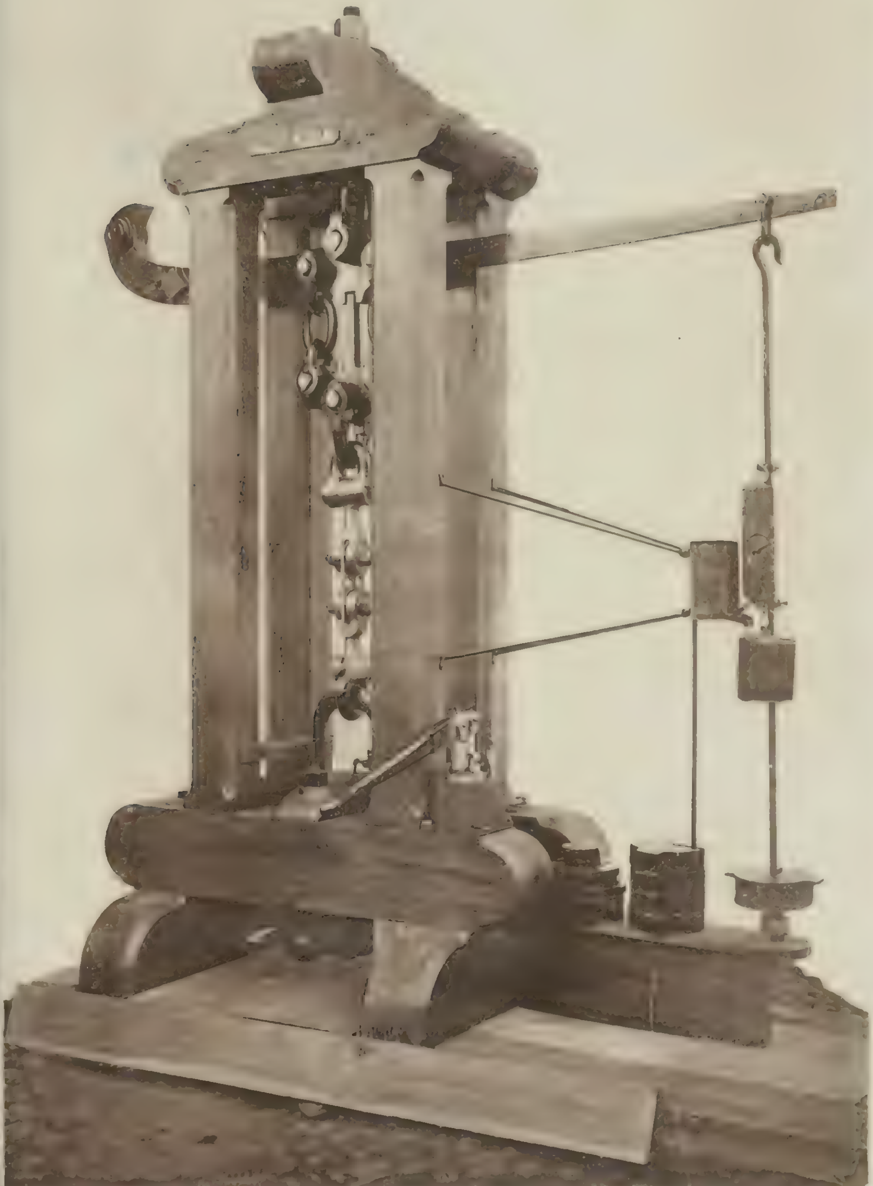
In order to weigh the strain with great accuracy, a self-acting weighing apparatus is attached, consisting of two reservoirs, one containing small shot and secured to the frame of the machine; the other one empty, and suspended to a spring dial, which is fastened to the

weight rod. On this rod is a finger point which, as soon as the beam is out of equipose and raises, lifts a trap, and lets flow a sufficient quantity of shot from the reservoir that is fastened to the frame of the machine to restore the equilibrium of the beam, which, when done, the flow of shot ceases. The amount of weights on weight dish, together with the weight of shot registered on spring dial, will indicate the amount of strain the test piece stood or at which it broke, as the case may be. By the use of this style of beam and jack with proper levers, machines can be made for applying all kinds of strains to all kinds of material, in any form, such as iron or stone columns, girders, bridge bolts, wire and hemp rope, chain, boiler plate, &c., &c., including the torsional strain. On this machine have been made some interesting tests for the Baldwin Locomotive Works; also for boiler plate manufacturers. This machine has been in use for several years, and after being subjected to the severest use, and frequent comparison with what is known as the "Government machine," has given great satisfaction. It is claimed that this machine can be made at less cost than any other of the same capacity, and for simplicity of construction and great strength, it appears to possess decided advantages.

Dank's Rotary Puddling Furnace.—The accompanying plate represents a perspective view of the machine puddler, which has recently attracted so much attention from the iron workers of this country and of England.

The immense advantages which would result from the construction of a machine by which the tedious manual operation of the ordinary puddling process might be performed mechanically, and with greater rapidity, certainty and regularity in quality of the product, have long been perceived by iron masters, and several attempts to solve the desirable problem have from time to time appeared; but not until the presentation, by Mr. Danks of his invention and the announcement of its performance, has this great desideratum approached a practical realization.

Upon the presentation of its claims before the British "Iron and Steel Institute," towards the close of the last year, this Association, with a promptness which affords the best evidence of the intelligence of its members, appointed a committee to visit America, in order to personally inspect and to report upon the operation of the machine puddler. The labors of this committee are now finished, and its report has just been published. This report is a practical acknowledgment of the successful solution of the problem of machine puddling, and a



PROVED TESTING MACHINE, Manufactured at the Philadelphia Scale Works

confirmation in every essential feature of the inventor's statements; and as such must be hailed with gratification as an assurance that another important step in advance has been made in the chief of the metallurgic arts. As a practical result, highly satisfactory doubtless to the inventor, we learn that an agreement has been entered into by Mr. Danks and a combination of English iron manufacturers of various districts, whereby the latter undertake to have 200 furnaces, on his plan, erected within six months, and, as a consideration, they agree to pay him at that time £50,000.

The following is a general description of the furnace and accessories condensed from the report above referred to:

"Dank's rotary puddling furnace consists of a horizontal revolving chamber, which chamber intersects the fire-grate and an elbow flue leading to the uptake of the chimney. The shape of this chamber, when fettled, partakes of an ellipse. The two ends are brought in by means of two cast iron rings forming a portion of the outer framework or structure. This structure rests by its periphery on four cast iron friction wheels, fixed in framings, and it revolves between the fixed grate or fire-place and the elbow-joint above referred to. The furnace is driven by a pair of vertical reversible trunk engines, the spur wheel on the crank shaft being geared direct into a toothed wheel forming the periphery of the rotary furnace. The rotary portion referred to is formed of several cast iron segments, which are held together by means of two cast iron rings before named, one at each end slipping over the ends of the said castings. The inner shape of the castings which form the chamber is a series of dovetails running longitudinally, which are for the purpose of mechanicaliy holding in the fix or fettling.

"The fire-grate is similar in construction to that of an ordinary furnace, the bridge being built in the end of the grate. It is provided with a pair of folding doors, which,-when closed and dabbed with clay, form a closed chamber. Air is provided by means of a fan, or blower —a portion is taken horizontally above the fuel, but the bulk is driven in underneath the bars.

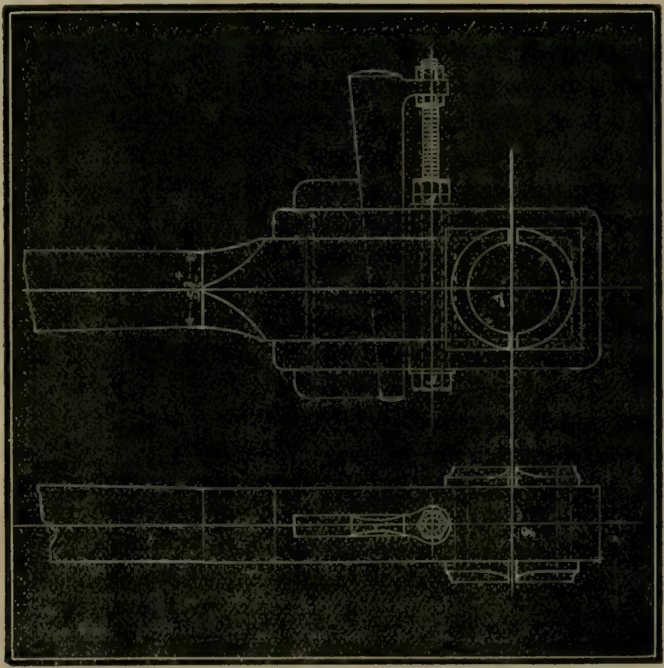
"The elbow joint, above referred to, forms the flue end of the whole apparatus, and it makes a short turn at right angles leading to the uptake of the chimney. The object of having this elbow connection is to allow of its being readily removed, in order to get at the interior cf the revolving chamber. The piece, or connection, is suspended to a way above by means of a chain attached to a pinion,

which pinion runs into a rack above. A pulley and chain are fixed on the same axis as the pinion, and, by means of these, the apparatus is removed and replaced at will.

"The two rings, forming the ends of the fire-bridge and elbow joint, are provided with water pipes cast in them, by which means they are kept cool."

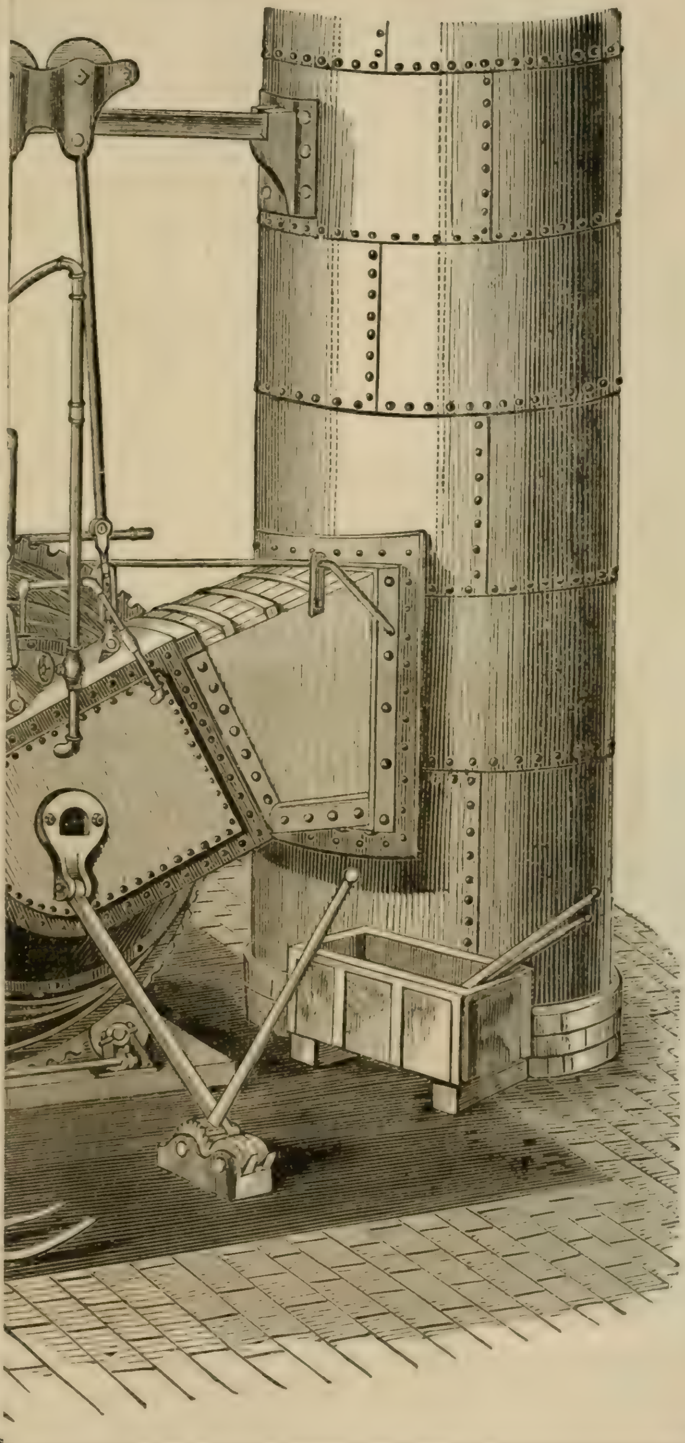
The tools for charging and removing the product consist: First, of a charging pan of scoop shape, capable of holding the full charge of pig together with the squeezer slag. Second, of a fork for removing the charge, which is operated, as is also the charging pan, with the aid of a crane. Third, of a receiving fork for receiving the ball and conveying to squeezer. The squeezer has been somewhat modified to work the heavy masses of iron produced in the furnace.

A New Stub-End.—Below is a sketch of stub designed by the writer for the crank-pin end of the connecting rods of four vertical engines of 400 horse-power, now building at the Port Richmond Iron Works, of this city, for a rolling mill at Scranton, Pa. Their shafts



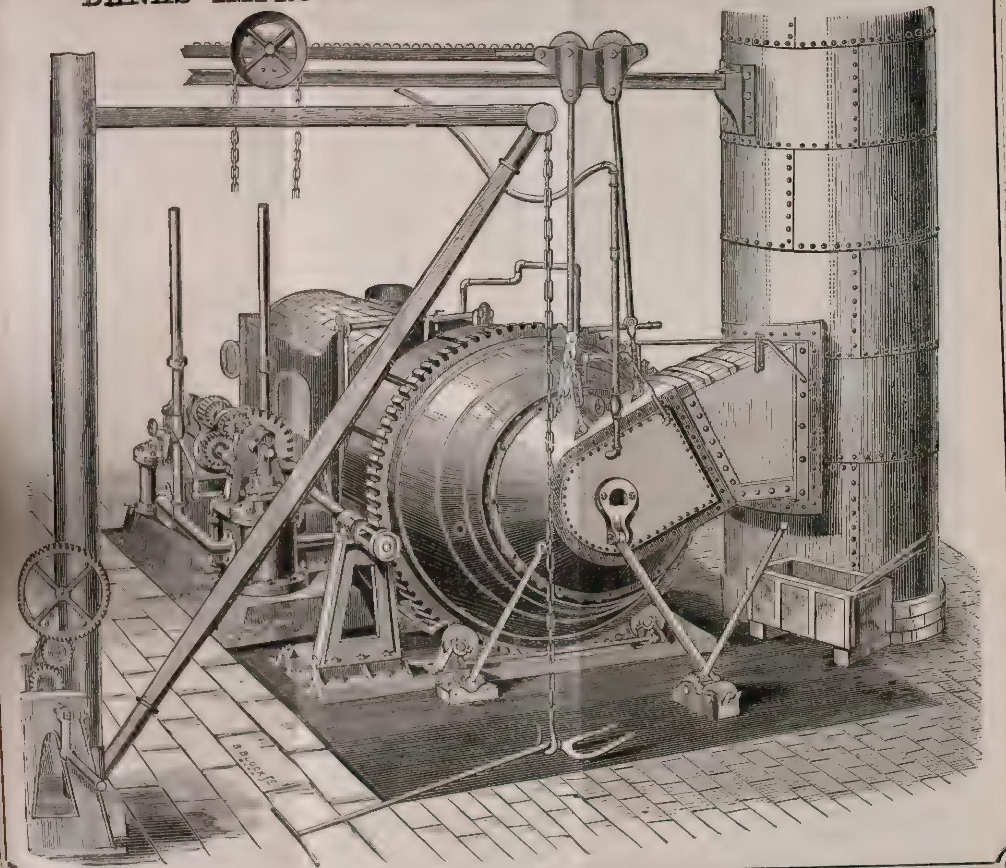
are to attach directly to the trains of rolls, and consequently a high speed is required, or seventy-five revolutions per minute.

UDDLING FURNACE.



FOLD-OUT

DANKS' IMPROVED PATENT PUDDLING FURNACE.



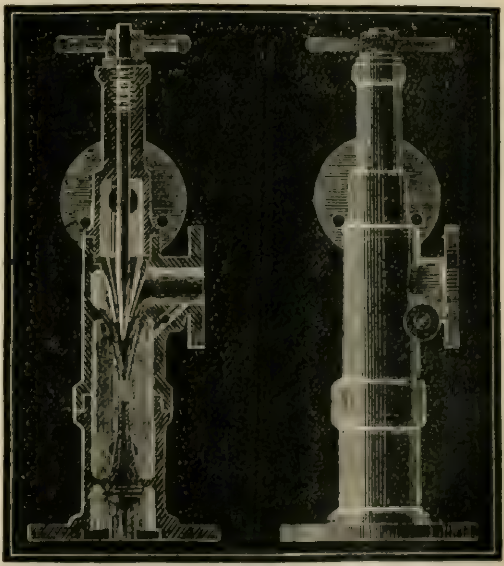
The connecting rods are heavy, having necks of $5\frac{3}{4}''$ diam., and boxes to suit a pin of $7''$ diam. by $9''$ length, and the blow resulting from the change of motions strongly tends to make the strap gape on alternate sides.

To counteract this the bolt A is passed through very near the end of stub, the strap having oblong holes to allow for draft.

To hold the key in adjustment, and from flying out, a continuation of the same bolt, but of reduced diameter, passes through the lug B, of key, which it holds by nuts on each side. The rest of the parts are made in the usual way, except the stub, which is somewhat longer than ordinary.

Whilst no novel parts are introduced, the combination of old features is believed to be new, and the removal of the holding screw from its customary place on the gib head avoids the difficulties of making and keeping straight those of large size, and for the same amount of draft the key can be shorter, as the height of the nuts on bolt is less than that of gib head. W. J.

Bourne's Feed-Water Heater.—"This feed-water heater embodies a new principle in mechanics, namely, that of forcing water by a pump through a small orifice at such a velocity that its energy enables it to enter the boiler.



"But the naked jet being passed through the waste steam from the engine condenses part of this steam, and is thereby itself heated to (200°) nearly the boiling point.

"The figures give an elevation and section of the instrument for effecting this object.

"The water is conducted from the feed-pump through the highest pipe, and the waste steam from the engine through the second highest, while the lowest opening is an

escape-orifice for superfluous water. The instrument in its configuration resembles a Giffard's injector. But the water enters at the point where the steam enters in that instrument, and the steam enters where the water enters; so that this instrument is the converse of the injector." J. H. C.

The American Steamship Company.—From the report presented at the first annual meeting of the stockholders of the company, held at the rooms of the Board of Trade, Philadelphia, it appears that a contract has been entered into with the Messrs. Cramp, Philadelphia, for the construction of four first-class iron propellers, all to be alike in model and machinery, and the material to be used in their construction to be, as far as practicable, of American manufacture.

Each vessel is to be of 3,016 tons (old measurement), 355 feet in length, 43 feet beam, and furnished with compound, vertical, direct-acting, surface-condensing, propelling engines. They are to be arranged to carry 76 first-class and 854 steerage passengers, and the total cost of the four is to be $2,080,000. It is expected the first of these vessels will be launched in June next, and the last in January, 1873.

The Detroit River Tunnel.—The following account of the present condition of this work has been made public:

The shaft on the Detroit side of the river was commenced early in December, 1871, and finished in January, 1872, when bed-rock was reached at the depth of 108 feet below surface of river. The whole depth of masonry is 114 feet. The lower twenty-five feet of this has a diameter of nine feet, with 12-inch walls. The drainage tunnel or drift starts from the lower portion of shaft, 8 feet above the rock. The drainage drift has been excavated under the river to a point 130 feet from the shaft, a daily average of over five feet. The ground through which it passes is a very hard clay, which must be dug up with picks. A layer of large boulders was met with in this stratum, some of which had to be removed by blasting, rendering the progress of the work slow. Should this layer fortunately dip beneath the level of the drift, the progress of the work would be at once doubled.

The hardness of the clay affords ample security for the work, portions of this drift having stood for a week without support, and without exhibiting any signs of sinking.

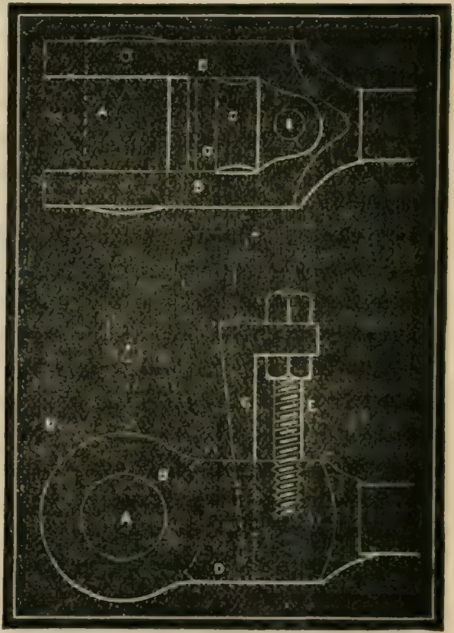
The lining, which is generally built within a day or two after excavation, is an 8-inch circle of the hardest bricks, previously tested, and laid in hydraulic cement.

Within a few days work will be commenced on the shaft Windsor, and as soon as it is sunk the drainage tunnel will be excavated from it to meet that now being worked from this side of the river.

From what was learned of the nature of the ground in sinking the shaft, it is anticipated that the main tunnels will be surrounded on all sides with good solid blue clay.

The progress of the work has thus far been very satisfactory, and there is every reason to believe that it will rapidly be brought to a successful termination.

A Joint.—A simple and neat adjustable joint is made by adapting a bearing block D to the outside of the eye-end through which the pin A goes, and which is made truly cylindric and concentric with the pin for that purpose.



The block is adjusted by the key C, which is forced and secured by the bolt and jam nuts E. The pin A is fastened to the fork B by a cross pin or other known means. The blocks D may be made by forming four together in one pattern, boring them out while thus united and facing sides in the lathe, then cutting them apart and fitting each to its place.

J. H. C.

A Permanganate Battery.—Mr. J. H. Koosen has experimented upon the substitution of permanganate of potassa for the nitric acid of the Grove Platinum Battery, and asserts that the electromotive force of this combination is greater than that of the Grove.

The following combination—platinum in a solution of permanganate with $\frac{1}{30}$ of sulphuric acid added, and amalgamated zinc in diluted sulphuric acid—gave the electromotive force as the average of more than one hundred measurements, to be between 1·9 and 2·2 (Daniel, 1.)

Preparation of Artificial Alizarin.—The important discovery by Graebe and Liebermann, namely, the artificial production of alizarin, the coloring principle of the madder, has as yet borne no decided practical fruits, from the laborious and costly nature of the operations involved. That it is not altogether overlooked by those engaged in the manufacture and use of dye stuffs will appear from the fact that quite recently two processes for the manufacture of alizarin have been patented abroad. That of Messrs. Bronner and Grutzkow, of Frankfort, consists in obtaining anthracene by the distillation of asphaltum with superheated steam. This is converted into anthrachinone by treatment with double its weight of nitric acid (sp. gr. 1·3 to 1·5). This is dissolved in warm sulphuric acid, and nitrate of protoxide of mercury is added. This compound is treated with an alkali, and the resulting solution is precipitated with an acid. The product thus obtained contains variable quantities of alizarin and purpurin. Redissolving in alkali and reprecipitation with acid is resorted to for purification.

Dale and Schorlemmer proceed as follows: One part of anthracene is boiled with four to ten parts of sulphuric acid, diluted with water, neutralized with a carbonate (of baryta or soda, &c.), and the resulting sulphates removed by filtration or crystallization.

The liquid is then digested with a caustic alkali, to which has been added a quantity of nitrate or chlorate of potash, and this continued until a blue-violet color is no longer produced. From this product the alizarin is obtained by precipitation with an acid.

Fluorescence.—At a recent meeting of the American Institute, Professor Morton read a paper on "Fluorescence," or that action by which rays of the higher purple, or even invisible light, such as produce most strongly photographic action, excite in certain bodies lower rates of vibration, resulting in the emission of light, generally of a red, green, or clear blue color. This paper was illustrated by a number of striking experiments. Thus, a flask of solution of chlorophyl (a green coloring matter obtained from leaves), which is of an olive-green color, being held in a beam of blue light proceeding from a "vertical lantern," appeared to be full of a blood-red liquid. Various solutions, colorless in ordinary light, were then shown to exhibit the brightest hues when illuminated by the violet rays of the lantern, or those obtained from the electrical discharge of the Professor's large coil in rarified gases. The speaker then announced that in the course of the examination which he had been making of such substances, he

had encountered one which he believed to be as yet unknown, and which possessed the property of developing light by fluorescence in a pre-eminent degree. This body was obtained from petroleum, and he would propose to take for it the name "Viridine." The word viridine had been already applied as a synonym for chlorophyl, but was now practically obsolete, and too appropriate to the present substance to be thrown away. The material from which this new body was extracted was given to the speaker by Prof. Horsford, of Cambridge, Mass., and by him in turn received from Dr. H. C. Tweddle, of Pittsburg, Penn. A large drawing of a flower, with leaves painted seemingly in light umber tints, was then shown and illuminated by electric discharges, when it appeared of the most vivid green. The peculiar fluorescent spectrum of this body, and its relations to the spectra of other substances was explained, and many other illustrations were exhibited.

Lithofracteur.—From Mr. Abel's recent analyses of this explosive, which, from the prominence given to it during the recent war, bids fair to play an important part in warfare as well as in the arts of peace, its composition is given as follows:

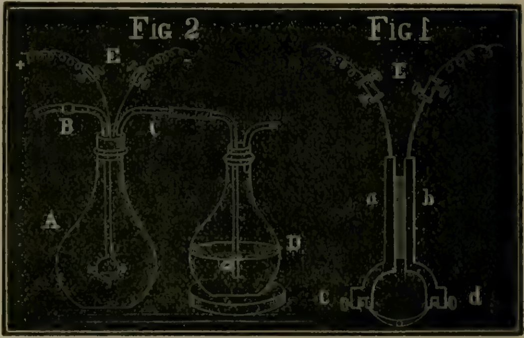
Nitro-glycerin, ...	42	parts.
Nitrate of soda, ...	25	"
Sulphur, ...	4	"
Sand, siliceous earth, saw-dust and coarsely-powdered coal, ...	29	"
	100	"

From the recorded statements concerning its properties, it appears that it may be cast into a fierce flame without explosion. It may be subjected to heavy blows with the same result; but when fired by a detonating fuse it explodes with inconceivable violence. A recent practical illustration of its efficiency was given a few weeks ago in the removal, with three charges of this material, of a wreck in an English river, which seriously impeded navigation. The first charge of fifty pounds, placed in the after hatch, sufficed to remove the whole of the after part of the sunken vessel; the result being the projection of a huge mass of water, sand, timber—including the main-mast—and débris to a height of about 100 feet. A similar charge was placed in the forepart of the vessel, the explosion of which removed the whole of the obstruction except the sternpost, which was imbedded in the sand. A small charge placed beneath this brought it to the surface in fragments.

A Lecture Experiment.—To demonstrate the combustibility of the diamond and of the graphite, Mr. B. C. Woodward makes use of the arrangement described below.

The ordinary method is that of heating the diamond before the blowpipe in a platinum spoon, and plunging it directly into an atmosphere of oxygen. This plan is, however, difficult of success; the diamond, if not very small, requiring several heatings to start the combustion; or, if very small, the phenomenon lasts but a second or two.

To meet the several objections, Mr. W.* takes a flask of about one litre capacity, and through the centre of the caoutchouc stopper with which it is furnished, passes two thin strips of brass, insulated from each other by a strip of bone (Fig. 1). Between the clamps c and d, which terminate the strips, is attached a thin strip of platinum foil, with a cup-shaped depression to receive the diamond. The upper ends of the brass strips, which emerge



from the stopper, are provided with binding screws for attaching to a battery. In addition to the arrangement above described, the flask A is provided with two glass tubes, one of them, B, connecting with a reservoir of oxygen; the other, C, with a flask, D, fitted up like a wash bottle, and containing lime-water.

The oxygen is allowed to bubble through the wash bottle for a few seconds, to show that no turbidity is produced, and the binding screws then connected with a strong battery. The strip of foil holding the diamond becomes instantly heated, and the latter starts into combustion. The product of combustion passes into D, and indicates its presence by the milkiness of its contents. The apparatus is said to answer equally well for graphite.

Resounding Flames.—During the course of some experiments upon this attractive subject, Mr. H. Planeth has found that any flame whether that of a candle or gas flame, can be made to sing without the

* Chem. News, xxv, 127.

aid of a surrounding pipe or chimney, by simply bringing into its neighborhood the leg of a sounding tuning fork. He finds that, by approaching any freely burning flame in this manner, a loud tone is suddenly heard, though before the sound of the fork was hardly audible. If a strong gas flame is used for the experiment, the sound produced is at least as loud as that obtained on placing the fork upon a sounding box. The strongest sound is obtained upon placing the flame between the prongs of the fork.*

The author believes the phenomenon above described to be closely allied to that of the singing flames so well described by Tyndall and other experimenters. In the singing flames, however, the body of the flame is the material excitant of the sound waves, and the surrounding pipe, the resounding portion; while, in the present case, the fork excites the waves and the flame assumes the part of resonance.

On the Extinguishing of the Electric Light by the Approach of a Magnet.—By Prof. Edwin J. Houston.—Having occasion recently to set up a large battery for experimental illustration of the properties of the light of the voltaic arch, I noticed a fact which I believe has hitherto escaped observation.

The battery consisted of about eighty half-gallon cells; fifty-five were Browning's modification of the nitric acid battery of Grove. The negative element consists of sawed strips of very dense coke, the positive element of zinc, so arranged as to use both surfaces of the coke. The remaining cells were of the iron battery.

When first set up, the arch between the carbon electrodes measured fully two inches, while the flame frequently reached an equal distance above the upper carbon. The quantity of the current was very good, much better, in fact, than the size of the plates would have led me to expect.

The phenomenon to which I would call attention is as follows:

Wishing to show the well-known experiment of the rotation of the light by a magnet, I approached a compound bar magnet to the light, holding it with one end pointing directly to the arch, in a horizontal plane equidistant between the carbon electrodes. When the nearest end of the magnet was four inches from the electrodes, the light was instantly extinguished.

The regulator of the light which was employed is a form recently patented by Browning, of London. The carbon points are kept at a

* Pogg. Annalen, cxliv, 639.

constant distance from each other by the action of a small magnet worked by the battery current. Though inapplicable to small batteries, for the current I employed it gave a light admirable for its steadiness.

Thinking that the extinguishing of the light was produced by some cause other than the approach of the magnet, the experiment was repeatedly tried in a number of ways, until it was clearly shown that the cause could not be attributed to accident, but to the approach of the magnet.

Though I have failed to find any published notice of this phenomenon, it seems probable that it may already have been observed, as the conditions of the experiment would be almost exactly reproduced whenever the rotation of the light of the voltaic arch by the magnet was tried. Still it may be conceived that though the necessary conditions for success in this experiment have often been *nearly* reproduced, they have seldom, if ever, been exactly reproduced; for it was noticed that in no case was the light extinguished, unless the length of the arch was nearly as great as the tension of the electricity admitted; that is unless the electrodes were separated by nearly their maximum distance, consistent with the passage of the current. Were this condition not observed in all cases, the approach of the magnet produced no other effect than the rotation of the light, until it assumed a position in a vertical plane 90° from a similar plane passing through the magnetic axis of the bar. Then, again, another necessary condition is that both the tension and the quantity of the current be of a strength greater than that of the current on which the experiment of rotation is generally tried. I have experimented with flames when these latter conditions were absent, and although the rotation was observed, the extinguishing of the light was in no instance produced.

The compound bar magnet employed is formed of three bars, held together by brass screws. It is one foot long, one inch broad and three-quarters of an inch thick, and is not at all remarkable for the strength of its magnetism.

As to the cause of the phenomenon, I think it may be attributed to the tendency of the flame to rotate on the approach of the magnet. This might cause the extinguishing of the light in two ways; either by the irregularities on the surfaces of the carbon electrodes offering greater resistance to the passage of the current from some points than from others, or by the current being unable to pass through the greater

distance of the arched path, which is always assumed by the light on the approach of a magnet.

Another assumption, which, though perhaps not as simple as those already mentioned, at least as probable, is that on the approach of the magnet, there is a slight increase in the non-conducting power of the medium between the electrodes, produced by their polarization, and which, though always acting, can only manifest itself in a striking manner when the distance between the electrodes is near a maximum, and the tension of the current is exerted to its utmost in passing through the non-conducting medium.

This assumption of the polarization of the medium between the electrodes, and its consequently diminished power of conducting the current, seems to be somewhat sustained by the fact, that a powerful electro-magnet, in the form of a horse shoe, when approached, did not extinguish the light, although it produced rotation of the current, for we may conceive that the two poles, acting simultaneously on the medium, would neutralize each others effects.

I noticed, on several occasions, that the south pole of the magnet would not extinguish the light until it was approached one inch nearer than the north pole, namely, to within three inches of the electrodes. This, however, may have been accidental.

Dept. Physics, Central High School, Philada., April 12th, 1872.

Puddling by Petroleum.—It is asserted by the French technical journals that the experiment of using petroleum as fuel in the puddling furnace, which has been in progress at a large iron producing establishment during the past three months, has proved itself to be very successful. In point of convenience, efficiency and in the superior quality of the iron produced, it is asserted that petroleum affords the best fuel that has yet been employed.

The Passivity of Iron.—The item noted in our January issue, on the passivity of cadmium, in which Schönn's experiments were commented upon in their relation to the analogous phenomena presented by iron, was so extensively circulated as to warrant the presumption that a few remarks upon the latter case will not prove uninteresting. A brief recapitulation of some of the more striking properties of passive iron is herewith given.

It is well known that nitric acid in a diluted condition attacks the metals more energetically than when concentrated; the red fuming

liquid containing hyponitric acid and other nitrogen oxides is here excepted. With this fact some curious results are connected.

If iron is immersed in concentrated nitric acid, (the pure monohydrated acid answers best,) it will be momentarily attacked, as will be evidenced by the evolution of gas bubbles from its surface; this, however, very shortly ceases, and no further action is visible.

If a similar piece of iron is immersed in the same acid diluted with an equal bulk of water, chemical action at once ensues and continues with energy until either iron or acid is exhausted. So much for the relative oxidizing effects of concentrated and diluted acid. Let the experiment be varied as follows.

Prepare two glasses, the one containing the monohydrated, the other the diluted, acid. Plunge into the latter a rod of iron, which will be vigorously dissolved. Remove it now into the first glass, and the dissolving action will almost instantly cease; return it after a few moments to the diluted acid, and it will remain there entirely unaffected.

The contact with the concentrated acid appears, therefore, to have so altered the surface of the metal as to render it entirely indifferent to the presence of chemical agents, to which before it was highly sensitive. Without implying the possibility of the transmutability of the elements, (which, it may be incidentally remarked, seems far less absurd with our present knowledge than it did twenty-five years ago,) it really appears that the surface of the altered iron has acquired the properties which render it more electro-negative than normal iron; so that if the two are brought in contact, immersed in an exciting liquid, they will generate a galvanic current; an effect which is universally regarded to predicate the contact of two unlike elements. The liberation of hydrogen *in statu nascendi*, on the surface of the altered metal, appears, however, to have the effect of bringing it back again to its normal condition; for the current shortly ceases to flow. To illustrate the foregoing, the following experiment will suffice.

Let the altered rod, which remains unaffected in the diluted acid, be touched for a moment with a rod of iron which has not previously been immersed in concentrated acid, and it will instantly be attacked; or, dip such a rod, after immersion in a mono-hydrated acid, into a copper salt solution, and it will be found to remain entirely free from copper—(a proof, it would seem, that the altered surface is electro-negative even to copper); remove it now and touch it for a moment with a piece of normal iron, and it will instantly coat itself with copper,

reducing the thin film of the salt remaining on its surface. Upon the explanation above mentioned, which may or may not be correct, the contact of the two pieces of metal generates an electric current; hydrogen is liberated upon the negative or altered iron, converting it again to its ordinary state. The moment this takes place, the diluted acid, in the first case, seizes upon it; or, in the second, the copper salt is reduced.

For want of a better explanation for the curious facts here noted, that offered above must answer. In conclusion, it may be remarked that a very cheap and efficient form of battery—the Maynooth iron battery—the outer cell of which consists of a vessel of passive iron containing concentrated nitric and sulphuric acids, has been constructed by taking advantage of the indifference to the action of acids which may so easily be established in iron as above described.

Bibliographical Notices.

Nystrom's Pocket-Book of Mechanics and Engineering, eleventh edition, revised and enlarged with original matter, has been received from Lippincott & Co.

This well-known pocket-book has now been increased to over 500 pages, containing much valuable matter of original conception, and the great variety of subjects, in form of tables and formulas, with practical examples, are well arranged.

Dynamics, pages 262, 310 and 311. The author classifies dynamical terms as follow: *Force, motion* and *time* are simple physical elements; *power, space, work* and *momentum* are functions of the aforesaid elements. This, he maintains, are all the terms necessary in dynamics. A list is given of confused dynamical terms, including *moment of inertia*, which he proposes to abolish.

Examples are given for the dynamics of fly-wheels, in which the term *moment of inertia* ought to occupy an important function, but does not appear in the formulas or calculations. *Moment of inertia* is a long-established term in dynamics, but is disregarded by Mr. Nystrom, and, however right or wrong he may be in the philosophy of dynamics, his reasoning is well worthy of attention.

The formulas for the flow of water in bends of pipes, page 342, appear to be new. The barometrical tables for the measurement of

heights, in English and French measures, pages 364 to 370, are very complete, and have been arranged by the author from actual practice in the Andes.

Logarithms of trigonometrical functions for every minute of a degree, or for every four seconds of time, also the eight trigonometrical functions for angles, expressed either in degrees or in time, as may be required, are the best arranged tables we have seen.

The author gives an original illustration, with formulas, for the expansion of bodies by heat, at and near the temperature of fusion, page 384.

Properties of inflamed gunpowder, and its dynamics in heavy ordnance, page 393. The author thinks that the charge ought to be so arranged that a slow powder is first ignited, then a quicker, and at last the quickest, by which, he says, the gun would be less strained and greater effect in the projectile secured.

Properties of water and steam in relation to heat, with formulas and tables, will be found extremely useful.

Formulas for the ultimate strength of flues for external pressure to collapse, are given on page 425, in which Mr. Nystrom says that the strength is inversely as the *square root* of the length, whilst Mr. Fairbairn has determined by experiments that the strength is inverse simply as the length. This is an important question in the strength and safety of steam boilers: both cannot be right.

On page 428, radiation of heat from steam pipes, boilers and steam cylinders, is an important article for the economy of steam and fuel.

On page 446, on the parabolic construction of ships, is very much the same as has appeared in the "Journal of the Franklin Institute," only that the formulas are more simple and less in number, and the tables are more complete. A formula is given on page 448 by which, the author says, any form of a ship can be recorded, and by which a ship-builder, familiar with the parabolic method, can construct a ship of a definite form. It appears that this parabolic method is a positive rule for the construction of ships of any form.

The properties of various explosives used for blasting are described upon page 473.

The additions to the eleventh edition are very appropriate, and greatly increase the usefulness of this standard book of reference.

Civil and Mechanical Engineering.

INTEROCEANIC COMMUNICATION ACROSS CENTRAL AMERICA.

By Prof. J. E. Nourse, U. S. N.

(Continued from page 383, Vol. LXII.)

The line of our narrative, which will offer a brief sketch of each important route, may here give place to some tabulated lists. The first of these is invested with additional interest by its association with the name of one so well known through successful labor in the varied branches of useful research.

I. Humboldt's Nine Routes.

1. River Columbia, to connect with Peace River, N. A.
2. Rio Colorado, to connect with Rio del Norte, Texas.
3. The Tehuantepec line.
4. The Nicaragua line.
5. The Panama line.
6. Cupica Bay and Rio Naipi with the Atrato.
7. The (supposed) Raspadura Canal: Rio Quito with the Pacific.
8. Rio Guallaga to connect with the Para, Brazil.
9. Gulf of St. George with W. coast of S. America.

A curious map, "*assembling these*," as Humboldt's translator says, will be found in Vol. 2d of "New Spain," London edition, 1822. In his later days, Humboldt rejected all of these except those numbered above from 3 to 6, inclusive. He steadily urged a true and thorough exploration of Darien. It will be noted that his eye was on the whole Western coast of North and South America.

After the lapse of more than half a century, thorough surveys of the most Southern portion of this Isthmus have been made:—In 1852 by J. C. Trautwine, C. E., of Philadelphia; in 1853 by Messrs. Lane and Porter; in 1854 by Mr. Kennish; in 1858 by Lieut. Michler, U. S. A. and Lieut. Craven, U. S. N.; and, in 1870–1871, by Com'r T. O. Selfridge, U. S. N. The report of the last named officer now being made up for the Navy Department, offers promise of our realization of Humboldt's expectations of success through the Cupica line. [No. 6 of the above.]

Our second table will be taken chiefly from the "Annales des Voyages" of M. Malte Brun *fils*.

II. Projected Routes across Central America.

A. *Projected Canals.*

I. 1. *Tehuantepec:* Coatzacoalcos and Chicapa.

II. 2. Honduras. [Canal found impracticable.]

III. *Rio San Juan de Nicaragua; L. Nicaragua.*

3. Rio San Carlos, Gulf de Nicoya.
4. R. Nino: Tempisque. G. de Nicoya.
5. R. Sapoa, Bay Salinas.
6. R. San Juan del Sur.
7. Brito.

Lake Managua,

8. Rio Tamarinda.
9. Port Realejo.
10. Bay of Fonseca.

IV. *Panama.*

11. Gorgona, Panama.
12. Trinidad, Caymito.
13. Navy Bay. R. Chagres, R. Bonito, R. Bernardo.

V. *Darien.*

14. San Blas, R. Chepo.
15. Bay of Caledonia, Gulf of San Miguel.
16. Rivers Arguia, Paya, Tuyra, Gulf of S. Miguel.
17. *R. Napipi, Cupica.*
18. R. Truando, Kelley's I.
19. R. Tuyra, Gulf of Uraba or R. Atrato.
20. *Bay of Cupica, by an East line to the mouth of the Napipi, and through Atrato R. to G. Darien.*—(*Commander Selfridge, U. S. N.* 1871.

B. *Projected Railroads, or Carriage Roads.*

1. Coatzacoalcos to Gulf of Tehuantepec.
2. Bay of Honduras to Gulf of Fonseca.
3. Rio San Juan, Nicaragua, Managua, G. Fonseca.
4. Gorgon Bay, or Pim's Bay, N. of Greytown, Realejo.
5. Gorgon Bay, San Juan del Sur.
6. Port Limon and Caldera on Nicoya Gulf, Costa Rica.
7. Chiriqui Inlet, Golfo Dolce.
8. *Colon,* (*Aspinwall,*) *and Panama,* (R. R. finished 1855.)

A glance at the map shows this classification to be in geographical order from North to South.

Other (*paper*) routes might have been included above; but their impracticability and, in some cases, falsity, will be occasionally shown in the sketches of the chief lines on which we now enter.

THE TEHUANTEPEC ROUTE.

Topographical View of the Isthmus.

Mr. J. J. Williams, Chief Assistant of Gen'l Barnard's survey—made in 1850, for the Tehuantepec Railroad Co. of New Orleans—presents, in his report, a general topographical view, which is here chiefly used.

The only other survey worth naming, (that recently made by "the Tehuantepec and Nicaragua Expedition, Capt Shufeldt, U. S. N.,") has somewhat modified the statements of the first named report.

Mr. Williams says:—"The Isthmus of Tehuantepec is that part of Mexican territory which lies between the Gulf of Mexico and the Pacific Ocean where the seas approach each other nearest, within Mexican limits. The narrowness of the Isthmus and nearness of a transit here to the chief ports of New Spain, Vera Cruz and Acapulco, made this route one of the earliest for exploration. From the mouth of the Coatzacoalcos in 18° 8′ 20′ N. latitude and 94° 32′ 52′ West longitude to the harbor (?) of La Ventosa, on the Pacific, in 16° 11′ 15′ N. latitude and 95° 15′ 40′ West longitude, the distance in a direct line is 143½ miles, nearly due North and South." (The coast line on each ocean is thus nearly East and West; the basin of the Coatzacoalcos is, therefore, open to the "Northers." "Tehuantepec" is, itself, (as was noted by Humboldt,) the name of an impetuous N. N. Easter.)

"The Isthmus may be properly said to comprise three main divisions, more or less distinct in their general characteristics,—their topography, geological formation and salubrity. The first embraces the country extending from the Gulf to the base of the Cordillera; this may be called the Atlantic plains and is the least healthy. The second comprises the more elevated districts in the central part; these are said to be healthy. The third includes the level country bordering on the ocean or the south, and known as the Pacific plains, warmer and less healthy than the hill country."

The first division comprises a belt of country of some forty or fifty miles in breadth, of rich alluvial basins, the principal of which is that of the Coatzacoalcos, draining the northern slope of the Cordilleras. On the West of this river is the Tuxtla range of mountains, the chief peaks of which are of considerable height; and on the East of these

is Mt. Tecuanapa, surrounded by extensive plains, and having an elevation of 1200 or 1500 feet above the level of the Gulf. But with these and a few other exceptions, the country of this Northern division presents the appearance of a broad plain, entirely covered with dense forests.

"The second division, extending from the Jaltepec river on the North to within twenty or twenty-five miles of the Pacific coast, and comprising a strip of some forty miles in breadth on the west, and widening out towards the east, presents a great diversity of feature. The immense chain of the Cordillera here traverses the country; but instead of lofty volcanic peaks elsewhere found, there is a sudden depression of the range in its passage across this Isthmus at a point directly in the line of shortest communication between the two oceans, yet the elevated spurs and ridges traversing this country generally in an east and west direction, interpose serious obstacles.

"By a narrow opening or gap in the mountains we descend suddenly from these elevated table-lands to the Pacific plains, which form the southern or third division. These average about twenty miles in breadth from the base of the mountain to the Pacific coast, and descend on the meridian to the lagoons, presenting a uniformly gentle slope towards the sea. They are traversed by eight rivers, which discharge the drainage of the southern slope, seven of which empty into lagoons; the eighth, or Tehuantepec River, comes down by a northwesterly direction, and, passing by the city of the same name, discharges itself directly into the sea at the Bay of Ventosa. This Bay is formed by an indentation on the coast and the projection of the Cerro Moro on the West. It is but partially sheltered from the North winds by low ranges of hills from three to four miles distant.

"Of the streams watering the northern slope of the Isthmus, the most important by far is the Coatzacoalcos. It drains a large extent of country, and furnishes a natural channel for effecting in part the communication between the two oceans. Its mouth is about fifteen hundred feet in width, with a varying depth, the greatest being thirteen feet. The tides are not strong on this part of the Mexican coast; but when the heavy northerly winds blow, the waters of the river are heavily backed up, giving a sensible increase of depth on the bar."

Cortez, in an official dispatch to Charles V, speaks of the importance of this harbor as the best then to be found on the Gulf of Mexico. Giving the results of a survey made by his order, he says, "They found two and a half fathoms of water at its entrance in the shallowest part, and ascending twelve leagues, the least found was five fathoms."

These soundings in 1520 gave about the same depth over the bar at the mouth of the river as that which we now find. Mr. Williams considers this as proof that the material of which the bar is made does not change its position; there is promise, therefore, he says, of security to any work for deepening the channel at this point.

It appears from the elaborate Report of Mr. Williams, that the two harbors which should be the termini of either canal or railroad on this line, have but moderate claims for our regard, at least in their present state. They admit, however, of very satisfactory improvement at perhaps moderate expense. Mr. Williams says positively in regard to the Coatzacoalcos, "The fact of there being no delta at the mouth of the river, and the constancy of the depth upon the bar, which has remained unchanged, according to the history of the country, nearly three centuries, proves that it has attained its *regimen*, and indicates that any improvement by deepening the channel may be relied on as permanent." Of La Ventosa, on the Pacific, he says, "it can be used in its present condition in the same manner as Panama, by employing lighters." Is not the name, "La Ventosa," however, a historic record against it as a harbor? Would those who frequent this coast accept this parallel with Panama? Are not additional obstacles and yet more serious ones to be found in the length of the route, the heights to be overcome by numerous locks, and the want of a sufficient feeder for a canal? Such does not seem to exist within any reasonable nearness. This last named fact, with other discoveries valuable in the full and final solution of the problem, will be found in the notice of the U. S. Tehuantepec Expedition of 1870–71, at the close of this article.

Attempts to establish Communication.

In 1551, Lopez de Gomara, the author of the History of the Indies —a work highly praised by Humboldt—proposed a union of the oceans by *Tehuantepec*, Nicaragua and Chagres.

In 1745, prominent persons of Oaxaca memorialized the Viceroy of New Spain for a canalization of the "Guasacoalcos," and a continuation by the Sarabia. It has been already noted (p. 12) that this memorial was the occasion of an edict from Spain forbidding the subject to be again mentioned.

In 1771, occurred the following singular excitement. Among the artillery at the fortress of San Juan d'Ulloa, were found cannon evidently cast at Manilla. But as the Spaniards, up to this time, had never doubled either cape to reach the Phillipines, yet had traded

largely from Acapulco directly across the great sea, it was at once said these cannons must have crossed Mexico by ascending the Chimalapa, and, after being dragged over the "*divide*," by descending the Guasacoalcos. At this idea public sentiment was excited. For if such heavy ordnance had thus been brought over, was it not proof that here communication could be opened up? The Viceroy, Don Antonio Bucareli ordered a survey to be made by Cramer and Corral, the former being an engineer as well as the Governor of d'Ulloa. Their work must have been a reconnoisance only. It does not appear that they made any levelings, or determined any elevation. They pointed out that a good harbor failed the route on the Pacific side, and appear to have confirmed the feasibility of improvement of the mouth of the "Guasacoalcos." It can scarcely be believed that they reported the canal practicable without locks, or inclined plains.

Such reports, with others of like character following them, gave a good name to this Isthmus during the rest of that century. In 1814, the Spanish Cortes listened to the proposition of a Mexican Deputy, Señor Alaman, and decreed the construction of a canal. The political distractions immediately following, and the independence of Mexico, left the government of Spain without power to promote the scheme.

In 1824, Col. Juan de Orbegozo, an officer of high reputation, was ordered on an exploration, which he began in 1825, and in which he endeavored to measure the height of the sea level by means of the barometer. His instrument, however, proved to be unreliable. Orbegozo reported the Coatzacoalcos as navigable for sea-going vessels ten leagues into the interior; that the Chimalapa, looked to as the southern section of a canal, was navigable in the rainy season only; that there was a deficiency in the want of a feeder, and that the seaport of Tehuantepec was shallow and open to the Northers. He concluded his report by affirming that the canalization of the Isthmus of Tehuantepec remains a *problematic* and *gigantic* work; but he regarded it an easy work to offer up a good route of inland communication between the lagoons of Tehuantepec and the Guasacoalcos.

Garay's Exploration.

In 1842, Santa Anna, president of Mexico, made a liberal grant to Don Jose de Garay, in furtherance of his scheme of opening up a route across the Isthmus; a primary condition requiring him to cause a reliable survey to be made. Garay employed eminent engineers, at the head of whom was Señor Gaetono Moro.

Moro published his report in 1844. It attracted attention both in this country and abroad. The difficulties of the route, although partially dealt with by his officers, caused Garay himself, at an early stage, to abandon the scheme. Moro's report has been regarded as in some degree promising, in respect of the important point, the supply of a feeder, *until* the thorough survey by our Government in 1870. The following notes will show the estimate held of Moro's work at the time of his report. Mr. Henry Wheaton, U. S. Minister at Berlin, deeply interested by his association with Humboldt in the plans for interoceanic communication, made favorable notice of it in an elaborate discussion which formed part of an official communication from the President of the United States to Congress. Vice-President Dallas published an extended discussion favoring this route. Vide *Journal of the Franklin Institute*, Vol. XIV, 1847.

In the instructions to Mr. Trist, U. S. Commissioner, in 1847, for a Treaty of Peace with Mexico, he was authorized, in extending the boundaries of the United States, to offer thirty millions of dollars in place of fifteen, "provided the right of passage and transit across Tehunatepec be secured." The Mexican Government "absolutely denied or refused to concede any such right." This, it has been affirmed, "was wholly based on the ground of its having made a previous concession to Garay." Is it not also probable that the refusal was caused by the fact that the concession to the Government of the United States, as such, would have seemed to compromise the security of the Isthmus? for concessions have not been withheld by Mexico from companies or individuals. Under the ever changing governments, at least three liberal grants, in recent times, have issued. The grant to Garay virtually fell into the hands of Messrs. Manning, Mackintosh & Hargous, who associated themselves with a company in New Orleans, and sent Major (now Maj. Gen. Barnard,) with Williams for his assistant, to make the survey quoted in the outset of this paper. Finally, in 1869, a new Tehuantepec Railway Company, organized in New York, (Mr. Simon Stevens, President,) have recently sent a surveying party into the field, and are prosecuting their enterprise.

Latest Survey and Results.

Since the preceding sketch was made, the report of Capt. R. W. Shufeldt, U. S. N., of the Tehuantepec and Nicaragua Surveying Expedition, has been communicated to Congress. It will be found to be an honest, impartial and able account of the Isthmus. The officers

of the Navy in charge were Captain Shufeldt, Lt. Commanders Remey, Bartlett, Farquahar and Cooper; Surgeon, I. C. Spear; Civil Engineer, E. A. Fuertes. The following notes only are given from the Report. Captain Shufeldt's memorandum, submitted to the Navy Department before organizing the expedition, embraced the important ideas:—that a ship canal through some pass of the Isthmus "is a necessity for the present and prospective commerce of the world;" that America should select that route which, satisfying interoceanic demands, will also best develop American trade; that a route from some port in the Gulf of Mexico should have preference, because the American Navy, by using Key West and the Tortugas as their base, can always hold the Gulf and its transit, since the channels to it are, in the aggregate, not more than 200 miles wide; and that the Tehuantepec route is the shortest for us, offering a gain in distance of 1350 miles over Panama, and permitting a steamer to load on the Mississippi and discharge her cargo in twelve days at San Francisco.

The Expedition had for its plain purpose to test the validity of Garay's survey, in which Moro gave the height of Tarifa, the summit level, at 680 feet, and asserted the entire feasibility of providing a feeder for a ship canal by the junction of the Chicapa and Ostuta rivers; other streams proposed as feeders by Mr. Williams were also to be examined.

The Expedition reached Minatitlan early in November, 1870, and remained on the Isthmus until the following April. The Mexican Government promptly acceded to the wishes expressed by the United States; and also appointed a Commission of their own, which worked harmoniously with Capt. Shufeldt's party. President Juarez also provided a battalion of 600 men for their protection in the disturbed districts. The work of the Commission was executed with fidelity and with full thoroughness to demonstrate—

(1.) That the plan of Moro's to join the Chicapa and Ostuta is impracticable; and that if the junction were effected, the supply of water would be insufficient; nor can a supply be had from the streams in the vicinity of Tarifa or Chivela.

(2.) That the summit level, Tarifa, is 754 feet.

(3.) That the bar at the mouth of the Coatzacoalcos is deepening by natural causes, and can be easily dredged at moderate cost, and the harbor made one of the best on the Gulf, and—

(4.) That the Corte or Upper Coatzacoalcos can be made a sufficient

feeder, and, on the Pacific side, the Bay of Salina Cruz be also made a good harbor.

The line suggested for a canal by Capt. Shufeldt starts in the Coatzacoalcos at the Island of Iacamichapa, running through the river valley to the divide at Tarifa, and through that pass to Salina Cruz, the sea-port of Tehuantepec. Its length must be about 144 miles, requiring about 140 locks; and, for the line of the Corte feeder, a tunnel of three miles, with a deep cut of 22 feet, to reduce the summit level. The feeder would be 27 miles in length. The canal to have a breadth of 162 feet at the surface and 60 feet at the bottom, and a depth of 22 feet.

The report makes no estimates of total cost. It presents a reliable summary of disadvantages and of advantages; the most gratifying points in it being the promise of good harbors as termini.

The additions made to our knowledge of the present social and political condition of this unhappy country, of its volcanic character and of its unhealthiness, have all an important bearing on the practicability of executing a work which Capt. Shufeldt frankly says would call for a treaty, not a private concession, and for national resources and national guarantees. His report, completed by Lt. Commander Bartlett, gives just occasion for honorable tribute to the U. S. Navy and the Government of our country.

The Report of the Engineer, Mr. Fuertes, contains the following encouraging statement:

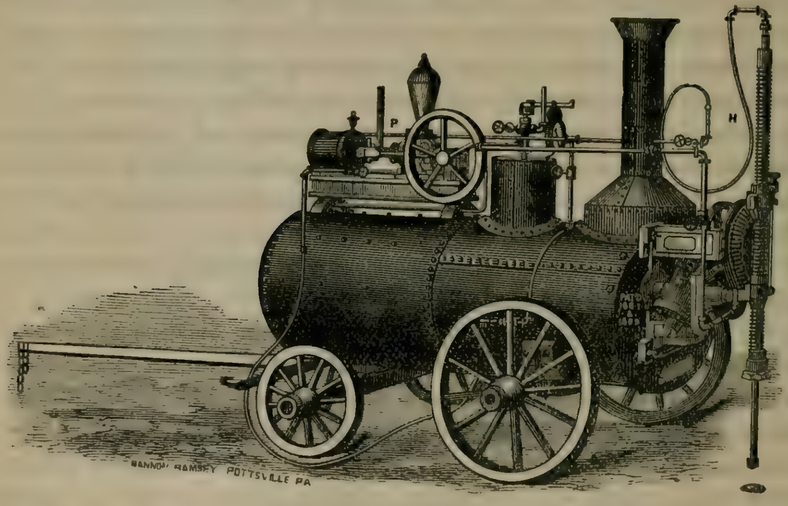
"The data obtained from our explorations and surveys prove that a ship canal is practicable on the Isthmus of Tehuantepec, because the difficulties to be encountered are of the ordinary type, or such as are inherent to works of a similar nature, with the difference that they will be met on a large scale. This fact is due to the assumed dimensions of the canal, and is inherent to the conception of the project in whatever part of the world it might be located."

Capt. Shufeldt himself, in his preliminary report to the Secretary of the Navy, April 18, 1871, says: "It is to me a source of great gratification to be able to say that an interoceanic surface canal of any necessary dimensions may be constructed across the Isthmus. * * * I make no estimate of its cost. It will be dear in point of money; cheap in point of American progress, peace and prosperity." —[New Route of Commerce, by Mr. Simon Stevens, Pres. T. R. R. Co., London, 1871.]

THE DIAMOND ROCK DRILL.

By John Warner, A. M.

Engineers and mechanics are acquainted with the process of boring metals with rotating drills made of hardened steel, but boring the hardest rocks with rotating drills set with diamonds for cutters is a recent invention which, although in use several years, will, I think, have the interest of novelty for most of the readers of the Journal. The invention is due to Prof. Leschot, a French engineer. It was used in completing the Mont Cenis Tunnel, and was favorably reported on by a commission at the Paris Exposition of 1867. The Pennsylvania Diamond Drill Company is now engaged in manufacturing and operating the Diamond Drill. By the kindness of M. H. Smith, Esq., of Pottsville, the Company's Resident Superintendent, I am enabled to present the following particulars:



The cut represents a Portable Steam Rock Drilling Machine, suitable for boring artesian wells, or test-holes in prospecting for coal or minerals; it weighs about 6000 lbs. Other machines, constructed on the same general principles with this, are made of various forms and sizes, for various kinds of work, as for quarrying, sinking shafts, mining and tunneling: these machines may be operated by steam or by compressed air.

Returning to the cut, the boiler is immediately recognized, and the machinery which operates the vertical drill is bolted against the end of the boiler.

This machinery consists of two oscillating steam cylinders, C, of six inches diameter and six inches stroke, working the same crank shaft; other details of the steam engines need not be noticed here. By a series of mitre wheels and other gearing, the revolution of the crank shaft produces the rotary motion and downward feeding of the vertical drill rod, or its speedy withdrawal, when desired, from the bore hole.

The drill rod is made of iron tubing, especially prepared, screwed together, from time to time, in sections, as the drill descends into the rock.

The drill rod passes through a larger tube, about ten feet long, having a screw thread upon the outside. This tube produces the so-called automatic differential and frictional screw feed, by means of which the feed motion and the pressure of the drill upon the rock are made independent of the weight of the drill rod, whatever may be the depth of the bore hole, so that the drill is rendered perfectly sensitive and, to a certain extent, self-adapting to the character of the rock, even when this varies extremely and suddenly in hardness.

The drill proper is screwed fast to the lower end of the drill rod. It is a metallic thimble, about four inches long, having a number of diamonds, either of the so-called black diamonds or of those translucent or partially crystallized, or of both, in their natural or rough state, firmly imbedded in the annular face of one end of the thimble; a female screw in the other end suffices to attach the drill to the drill rod. As the drill descends, a cylinder or core of stone is left standing inside of the hollow drill rod: a self-adjusting wedge is placed in a groove inside of the hollow drill; this wedge allows the core to pass freely up into the drill rod, but seizes the core and breaks it off and brings it to the surface when the drill is withdrawn. If the core is very large, it may be necessary to break it off at the bottom by an ingenious system, of which we shall not give details; frequently the core is broken by natural cleavages of the rock. The cores thus taken out, from time to time, give a perfect record of the lithological formations through which the drill has passed. It is also possible to use drills which make no core, cutting the hole in its whole diameter; but we continue to speak of the hollow drill.

An indispensable appendage is yet to be mentioned: this is a steam force-pump, P, here seen on top of the boiler. This pump draws a supply of water from any convenient reservoir, by means of a rubber hose, and in a similar manner forces the stream, through a swivel joint,

in at the upper end of the hollow drill rod, and thus to the bottom of the bore hole, where it moistens the rock, keeps the drill cool, and then ascends on the outside of the drill rod, carrying upwards the fine material or cuttings into which the rock is reduced by the diamonds set in the drill.

The principal parts of the machine above mentioned are, then, 1st, the boiler; 2d, the steam driving machinery and feed gear, with the drill-rod and drill; 3d, the force pump and stream of water. These parts may be connected with a vertical boiler, or they may be separated and placed at a distance each from the others, according to the nature of the work. It should be observed that the drill rod and feed gear can be so arranged as to permit boring in any desired direction, with convenient modes of shifting the direction at pleasure; and the same freedom of application may be obtained with compressed air for a motive power.

The speed of boring depends much upon the nature of the rock, varying, for a two-inch hole, which is suitable for test-holes, from four feet per hour, in hard rock, to ten feet per hour in sandstone and slate, with a rotary speed of three hundred revolutions per minute.

In the Pottsville region holes have been bored, in hard rock, as large as nine inches in diameter.

These machines are recommended by General H. Pleasants, Engineer of Mines of the Philadelphia and Reading Railroad Company, under whose direction they are now in use, near Pottsville, in sinking deep shafts upon coal lands belonging to that Company.

The speed with which the work of shafting and tunneling may be prosecuted, and the regularly cylindrical shape of the holes—an important matter in blasting—give these machines advantages over all others yet known for the same purposes.

MERRILL ON IRON TRUSS BRIDGES,

By Charles F. Johnson, Jr.,

(Engineer for the Kellogg Bridge Company.)

Although Colonel Merrill's work has been before the profession for some time, a few words on various subjects suggested by it may not be unseasonable. The subject of Iron Bridge Building is becoming so important, that any contribution to our knowledge of the economical distribution of material in an iron truss is valuable. A thorough and analytical work, like that of Colonel Merrill's, must therefore be

welcomed by every honest builder, though they may disagree with some of his positions. All can, however, endorse the following quotation:

"The effect of competition is such that many bridge builders, while professing to use 5 or 6 as their factor of safety, really use a much smaller number. It is to be hoped that every railroad engineer will so familiarize himself with the theory of bridge building, as to detect and prevent any such frauds on the companies and the public."

That portion of the book which is devoted to an examination of Hodgkinson's and Gordon's formulæ, and the graphic representations of their results by curved lines, is especially interesting. There is nothing more instructive than a graphic illustration of a law, and the thanks of all members of the profession are due to Colonel Merrill for his conscientious labor. A series of careful experiments on struts of the various sections we must necessarily use when wrought iron is the material employed, would leave nothing to be desired in our knowledge of this important subject. These are generally hollow squares or H sections, and the formula involving the radius of gyration has never received the seal of practical test. There is no form of truss where the strains are so fairly divided among the various members, as that with pin connections top and bottom. It is impossible to distort it by ignorant or careless adjustment. But since the pressure on the struts is applied through the medium of the pin, they partake of the nature of square and of round end pillars, square in a plane at right angles to the axis of the bridge, and round in a plane at right angles to the axis of the pin. What is the most advantageous section for struts in this condition is a point which remains to be decided. Probably it would prove to be a hollow square with three times as much material on two opposite sides as on the other two. It certainly would not be a cylinder.

As a practical question, Colonel Merrill has put his panel load for a locomotive too low—35,200 pounds. There are engines that throw from 25 to 30 tons on the drivers in a space of twelve feet. Nor is it safe to assume that only one engine could be on the bridge at a time; two are not unfrequently coupled. However, as his figures are assumed for the purpose of comparison merely, and as his weights for tender cars and structure are high, the point is of minor importance. His weights and method of computing strains are, we believe, those adopted by S. S. Post, the father of scientific bridge building in this country.

In his general discussion, Colonel Merrill says, "It is a well-known principle of mechanics, that any body acted upon by a system of forces in equilibrio, is affected by new forces as if the original forces did not exist."

This is a principle of dynamics rather than of statics, and strictly applies to a system of bodies free to move in space. Like all general principles, it must be applied with strict reference to its limitations. When one of the forces is the resistance of a stone abutment, capable of indefinite increase, and all of them are compelled to act in fixed lines through a medium so elastic as iron, the legitimate inferences from the principle are to a great extent controlled by these circumstances.

A book lies on the table before me in equilibrium between gravity and the resistance of the table. I toss another on it. If gravity and the resistance of the table did not exist, the books would move, but the resistance of the table meets the new demand, and the books remain at rest. This rude illustration may serve to show that it is possible to draw an incorrect inference from a general law.

From the principle above laid down, Colonel Merrill deduces the rule that equal weights, similarly situated on a bridge, balance one another, and assumes that the effect of the moving load is exactly the same as it would be if the bridge were devoid of weight, since the panel load of the structure and track applied at the feet of the several ties' balance one another and act as a set of forces in equilibrium. The practical result is that he finds counter-strains where none really exist, *i. e.*, in the counters nearest the abutments. That these counters are not affected by the moving load, follows from the principle that a strain in a counter and a tie which forms the other diagonal of the parallelogram cannot exist at the same time, and the permanent strain on the tie from the static load is greater than the strain on the counter from the moving load. Any cause which tautens one diagonal slackens the other. I speak of course of strains produced by extraneous causes, such as the load. Strains caused by screwing up the rods, affect each of them. Again, many trusses are built without these counters, for instance, the Pratt-Whipple; in this no counter is run to the foot of the first panels. A moment's consideration will show that if either of these points descend, every other point on the bridge must rise. The entire weight of the bridge balances a moving weight applied at these points, and experience proves that they are unyielding, unless the bridge is very light.

There is another consideration which militates against the theory of balanced weights. A double triangulation truss consists of two single triangulation trusses with a common top and bottom chord; weights on the floor beams of one system can have no effect on the ties, struts and counters of the other. Each system carries one half of the load independently, and the strains must be separately considered. If there is an uneven number of panels, the systems are not symmetrical longitudinally. Take a Pratt-Whipple over-grade, for instance, in which each truss can be separated into two systems.

It is evident that there can be no balancing of equal weights in this case, for the weights are not equally distant from the abutments. This consideration also shows that the common method of computing the strains in a double cancellated truss with an uneven number of panels is erroneous. The tie, instead of carrying one panel load of the static weight, carries only $\frac{6}{11}$, and the rod, instead of doing no duty, carries $\frac{5}{11}$ of the static load, and so on for the others. The method of equal moments avoids the error.

However, admitting that I am correct in supposing that the theory of balanced weights is misconceived by the author, the practical effect is of little consequence. The counters, which are invaluable for the purpose of lessening the amplitude of the vibrations of the structure, should always be made larger than this theory would call for.

I have not had time to give the remainder of Colonel Merrill's book the careful reading it deserves. It would seem strange, however, that he should make the top chord of a Linville Truss twenty-five feet high, only ten per cent. lighter than the top chord of a Post Truss, eighteen feet high, same span. Experience would suggest that there would be at least twenty-five per cent. difference. If there is any economy in the Post Truss, it is in the web and not in the flange of the girder. The top flange is in general a function of the span, the load and the depth, and the compressive strains in it cannot be much affected by the connection between it and the bottom flange. The weight of different trusses can be safely compared only by making out the bill of iron just as it would be ordered, and their stiffness by running a train onto them and measuring the deflection. Without correct theory we grope in the dark; with correct theory alone we are liable to stumble; with correct theory and carefully tabulated experiment, we are absolutely sure of our ground. Theory controls within the limits set by practical considerations, but the theory which makes the top chord of a high truss so little lighter than the top chord of a low truss, would

find some difficulty in making the low truss as stiff as the high one. There is nothing in which the practical common sense character of American engineering shows itself more distinctly than in the universal adoption of deep trusses.

ON FEED-WATER TO STEAM BOILERS.

By Ign. Hahn.

(Continued from Vol. LXII, page 405.)

First of all, permit me to allude to some inaccuracies, which I observed on reading my former article, viz. :

On the table of analyses, in analysis No. 4, the Silica is omitted, amounting to 0,13000; further, in No. VI, the free Sulphuric Acid should read 1,66200, instead of 1, as stated there, and finally let me add No. VII, as follows:

Chloride of Calcium,	0,11730
Sulphate of Lime,	0,94350
Carbonate of Lime,	0,72232
Carbonate of Magnesia,	0,35072
Sulphate of Iron,	0,90250
Silica,	0,01500
Organic matter,	4,68300
Residue left on evaporation,	8,56500
Mechanical impurities, likely coming into boiler,	63,17000
Total sediment,	71,73500

The mechanical impurities are added to the total chemically combined matter, under the presumption that the water is forced from the brook or creek directly into the boiler. Of all the 7 analyses, the water as represented by analysis No. I is the best; but No. II being easier of access, its impurities in quality and quantity still countable as exceptionally good or favorable ones, the latter will be used for the works of Boston Franklinite Company, in preference to No. I; the more as the Franklinite ore crushing and washing establishment of the Passaic Zinc Company, situated about one mile further up the creek, worked to their utmost capacity, at the time the water was taken for analysis, from which source it receives very likely a considerable part of its chemical and much mechanical impurities.

Speaking now of the Roaring Brook water, analyses of which are

shown by No. III to VII inclusive, it is obvious that No. III is superior to all, next comes No. IV, VII, V, and last No. VI; No. IV and VII are such as at present supplied to the city of Scranton for domestic purposes, by the Scranton Gas and Water Company, and is also used in a number of steam-boilers.

Owing to the larger amount of sulphate (of lime and iron) in the water from this place, it does not behave satisfactory in the boilers, inasmuch as the sulphate of lime has a tendency to attach so strongly to the iron of the boilers, that it can be removed only with great difficulty; blowing off by itself will carry away but very little of it, while the sulphate of iron is liable to slowly attack the iron of the boiler.

The sulphates do not appear to be in large proportion, but when compared with the total foreign matter, as chemically combined, are very large, being nearly 40 per cent. of the whole; thus but very little mixed with them to prevent their close contact with the iron all over. Still worse is the water from analyses V and VI, where free sulphuric acid is to be contended with, acting very injuriously upon the boilers.

Boilers, where this water is made use of, are being blown off partially from 6 to 8 times every 24 hours, and notwithstanding that the total impurity of the water in its natural state cannot be called excessive, yet each time it streams forth in an extremely muddy condition, and of a color plainly showing the destructive part it has played on the boiler-iron. This water, or rather the sulphuric acid in it, first commences eating up the edges of the rivet heads and the ends of the sheets, causing very frequent repairs.

This kind of injury is not so dangerous if well looked after, because it shows itself by water leaking through; it is different when it commences to attack the plain sheet, thus weakening the strength of the boiler to withstand the pressure of the steam within; which occurrence is the more detrimental, because it is not so easily detected, and occasionally may lead to an explosion ere the attendants of the boilers become aware of the existing peril.

In consideration of all this, the water, as represented by analysis No. III, will in future be used as well for the boilers of the Lackawanna Iron and Coal Company, as also for city supply, by the Scranton Gas and Water Company. The place from which this water is taken lies outside the coal measures, and, as already stated, about half a mile above the mouth of Dunmoore Creek, where for the first time, Roaring Brook receives mine water.

The proportionally large amount of sulphuric acid in IV to VII is derived partly from Dunmoore Creek, into which a number of collieries are emptying their mine water; further from mines along Roaring Brook, or near to it, and below mouth of Dunmoore Creek, as well as from heaps of culm, (waste-coal), slags, cinder, ashes, &c., piled up below that point, on both banks of Roaring Brook, all of which contain more or less sulphur, in such combinations as are soluble by water.

Concerning the unusually large proportion of organic matter in Nos. V and VI, it is necessary to mention that, for local reasons, both places are not kept as clean as the use to which the water is taken would demand; otherwise said substances would probably not exceed 8, instead of 16 and 19, as they amounted to then.

In the majority of waters, such as are used to feed steam-boilers, the carbonate salts are prevalent, and these are less troublesome than any of the other salts; free acids in water are in general only met with in extensively worked mineral regions and volcanic territory. Excluding the so-called mineral waters, containing often 1,000 and more pounds of foreign chemically combined matter in every 12,500 gallons of water, and which are seldom used for steam-boilers, the average quantity of foreign matter in other waters, rivers, spring and pump water used in boilers, foots up to about 40 pounds, at most, of sediment, on evaporation of 100,000 pounds of the water.

While this is probably the average, it may be well to call attention to the wide range within which that number is obtained, lying between half a pound to 300 pounds and over. Thus it will be seen that the general expression of, "why! water is water," has only value so far as humanity merely cares for its passing by; while, if compelled to make use of it, and reach a certain aim, which in this case is making steam, it will probably be preferred to look more closely into the matter. It will pay to use water that deposits but $\frac{1}{128}$th of an inch thick layer, in preference to another leaving a total residue (in the same time) of $4\frac{1}{2}$ inches in thickness, could either be had within a reasonable distance from a given locality. True, these are extreme cases, yet they serve to give a better idea of the problem.

However, accustomed to move and to meet every day's demands, the following calculation on an average quality of water will be given by me, in order to show how rapidly the sediment accumulates, even under such circumstances as are often practiced, viz: Admitting a boiler of 40 horse power; length of boiler 35 feet, diameter 4 feet 6 inches, with 2 flues, each 18 inches diameter, working to its full capa-

city, and uninterrupted day and night for a whole week, blowing off only at the end of the week. Sediment left on evaporation of 12,500 gallons, 40 pounds; specific gravity of the sediment, 2.4. Incrustation gathering equally thick on lower one-third of the circumference of the boiler, which presumption is near enough for this purpose; actually it is found to be thickest at lowest point, (and near the grate,) and thence decreasing to an edge, on either side toward the point where the flame or gases of combustion no longer reach the boilers, that is where the actual heating surface is at an end, and also some around the flues.

Under the conditions, as enumerated above, there is:

Total quantity of water required for whole week,	357,120 pounds.
Residue in boiler, derived from said water,	143 "
Thickness of incrustation at the end of the week.	$\frac{1}{15}$ inch,
or if allowed to run on for a whole month, which is often done, then the accumulation will be	$\frac{5}{16}$ inch,

which of course could be lessened by blowing off a little now and then during specified time. Now there are a good many works where the boilers are not cleaned until they utterly refuse producing steam of required pressure, notwithstanding that the double and triple amount of coal is consumed on the grate.

From such places I possess specimens of boiler incrustations three-fourths to one inch thick; naturally, with such a bad conducting lining inside the boiler, the latter must be kept red-hot, if steam at all shall be kept up by it. To say the least, it is certainly unwise to proceed thus; the little steam that is made is bought at a very heavy expense in coal, the iron is being blistered, and if (what occasionally does occur) anywhere a piece of the sediment separates from the rest, an explosion is almost the inevitable result, because under such circumstances the water suddenly comes into contact with the red-hot iron: steam is produced so rapidly, that in most cases it cannot escape quickly enough from the boiler, the steam pressure increases above the boiler's capacity of resistance, and off it goes.

The remedy for above named evils is:

To select of two or more waters at practicable command that which contains least foreign matter and no free muriatic acid, nor free sulphuric acid.

Should all waters, or the only water at disposition, carry the acids alluded to in a free state, then saturate the latter, either directly in the boiler or in a separate tank or reservoir, with, for instance, "pow-

dered raw bi-carbonate of soda," after which the boiler will remain intact.

Where the water is very impure, both chemically and mechanically, the last mentioned operation is best fulfilled in a reservoir, the more readily if the mechanical impurities are of such a character as to settle within 12 hours, when comparatively clear water will reach the boiler.

If the best water at hand cannot be obtained in sufficient quantity, take as much of it as is available, and use it in mixture with the other source of water, provided, of course, the additional cost of piping be not in excess of the advantages derived thereby.

In this way free muriatic acid or sulphuric acid in the one water can be saturated often by the other water, thus saving expense for treatment with artificial powders, which, for example, is the case when water of analysis No. III is mixed in sufficient quantity with that of No. V or VI; namely, the free sulphuric acid of V and VI being the stronger acid, will expel the carbonic acid of the carbonate of lime, &c., in No. III and form sulphate of lime, &c. If, for particular financial reasons, erection of tanks, reservoirs or artificial powder treatment cannot be resorted to or afforded, and yet the water is very impure, then blow off and clean out at shorter intervals, though it may be more expensive in a long run. Last, but not least, employ none but reliable and experienced men to attend the boilers, and allow them sufficient time to thoroughly clean the boiler whenever needed.

Whether, in a given locality, it be best to blow off frequently, which causes a larger consumption of fuel; to replace a boiler by a new one in perhaps every eight years; to treat the water with suitable materials in the boiler; or to erect reservoirs, in which to settle mechanical impurities, get rid of part of the organic matter, saturate free acids and even precipitate some of the chemically combined matter, by which means a boiler may be made to last 20 years or more—all this naturally depends on the quality of the water at disposal.

While in some instances the water needs no attention at all, in others again but ordinary care, there are some that occasion considerable loss in greater consumption of fuel, irregularity in the operation of works depending on such boilers, and by the shorter time they are serviceable.

To be sure on all these topics, and to get the most power out of a boiler at least expense, it seems proper, after the question of a sufficient supply is favorably settled, to have a chemical analysis of said water; should this examination show the necessity of treating

the water before entering the boiler, then prepare next one or more general plans of mechanical appliances needed, simply drawn in pencil and to scale, so as to be enabled to make a close estimate of cost of their execution. Of the different plans made, select that which offers most advantages, compare its cost, maintenance, (and materials for chemical treatment, if needed), with the savings in coal, in regularity of operation and longer endurance of the boiler, and if the account falls in favor of the additional appliances, then use the same; while if it shows the contrary, then of course dispense with them.

But even when the latter case should be found preferable, the preliminary work cannot be considered a loss, as by its means information is gained regarding the proper caution required to be observed in the use of the water, or rather, in the management of the boilers using such very impure water.

Finally it must be added that, in general, river water is better adapted to boiler purposes than either spring or well water, because its chemically combined foreign substances are mostly less than those in the latter waters; while the larger amount of mechanical impurities in river water can be separated more easily and cheaply from it than the chemical impurities of other waters.

Hyde Park, Pa., Feb. 23d, 1872.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 34.)

The relation of small shafting to hollow shafting.—"On small shafting, pulleys are used very much less in diameter, consequently the friction of the shafting is as its velocity. If the circumference of the pulley is used for the bearing, the friction is very much increased. The torsion of the hollow shafting is as the cube of its diameter; if you use a 3-inch shaft the torsion of that is as its cube. If you take from the centre of the shaft, you have left the outside shell only, so that the amount of power gained theoretically, is the amount of iron taken from the inside of the shaft, running upon the bearing of the outer.

"One difficulty in small shafting is in properly fastening the pulleys. The construction of this shafting is such, that it requires a larger diameter to hold the pulleys than to transmit the power; consequently, I have taken $1\frac{3}{16}$ inch diameter as the smallest shafting

that it is practicable to run in mills. An inch shaft, well sustained, will drive 100 looms; but you have to fasten to it the couplings, the pulleys, and set-screws; and if the holes are not properly drilled, the set-screws will cramp the shaft. After putting up a line 150 feet long, it is necessary to straighten it. You cannot straighten the line of shafting in the shop, because the pulleys are not made in the shop. In order to straighten the shafting, we take a lever, put it under the rail, and spring it into place.

"We are using a line of $2\frac{3}{16}$ inch shafting, driving 16,000 ring spindles. The quantity of oil required to lubricate this shafting is so small, that, if I tell you, it will seem almost impossible. I asked the overseer how much oil he used in oiling this shafting,—and he told me only two or three drops to a bearing, once a week; and said that he would run the whole line a year with a half pint of oil.

"I found one shaft had been running eighteen months with no dripping pans underneath; the overseer giving as a reason, that the quantity of oil consumed was so small that none were required. We all know that it requires oil to run a shaft, and we can form an idea of the amount of friction by the quantity of oil consumed.

"The line of $2\frac{3}{16}$ inch shafting, which drives 16,000 spindles, runs through a mill 350 feet long, and is fitted up with bearings 8 feet apart, and carries a reasonable share of pulleys which drive the machinery.

"I have adopted this method of having the main driving pulleys about once in 150 feet; and counter lines about 150 feet long, and belted in the middle. The middle shaft is made $2\frac{3}{16}$ inch diameter.

"If the pulleys are very small, it requires, to run at a slow speed, more power than it does through gears, on account of the strain which you are obliged to put upon the belt. In England it is the custom to use gears mostly to transmit the power, which requires a stiff shaft to hold them in place; consequently, a gear never yields; it must go. With a belt it is very different. In making the formula for shafting, I adopted as a standard one-fifth of the breaking weight. There is no pulley put on strong enough to run more than this; but with gears it must go.

"*Gearing.*—There are many ways of transmitting power from the motor to the machine, or place where it is to be utilized. I will invite your attention to the three that are commonly in use among our manufacturers, viz., Gearing, Shafting and Belting. Gearing and shafting transmit a uniform motion, that is, a certain number of revo-

lutions, but not always a uniform revolution, owing to the elasticity of the shaft or imperfect construction of the gearing. Power transmitted through pulleys by belts or straps is variable, and cannot be relied upon when uniform motion is required, owing to the elasticity and thickness of the belts, and their liability to slip. Power transmitted through gears and pulleys may have an increased or diminished velocity by having gears and pulleys of different diameters. But with shafting the velocity is positive, as by construction both ends of the shaft must run with the same number of revolutions. Each of these methods has its advantages, but neither motion in all cases can be made to supply the place of the others. When a positive ratio is required, between the driver and driven, it must be through gears; and as gears are universally used to transmit power from the water-wheel or water-wheel shaft to the second mover, let us for a few minutes consider gears and their formation. Possibly no part of mechanical science in common use is so poorly understood or wretchedly abused as the formation of gearing. Each draftsman or mechanic has his favorite tooth or form of tooth. It is his pet child and there is no other like it. To ask him to demonstrate or explain why it is better, would be considered almost an insult; but however perfect it may be in theory and construction, if the gears are not properly adjusted to each other, and made to run as designed, the whole theory and mechanism becomes useless, as the teeth are formed for a definite pitch and cannot be used for any other, either theoretically or practically, when a smooth motion is required.

"In forming teeth for gears we first draw what is called the *pitch line*, or circumference of uniform motion, which is the working diameter of the gears. The teeth are formed from this line, and it is indispensable to the smooth running of the gears that these lines should run together, otherwise there would be a grumbling noise or jar, like the rolling of a fluted roll over a plain hard surface. I think I can demonstrate to any geometrician, that a tooth similar to the epicycloidal and hypocycloidal tooth is the only one that can be made to run smoothly.

"This tooth is formed by having two circumferences run together corresponding to the pitch line or diameter of the required gears. However, as this is not the proper place to discuss theories, I will not occupy your time by doing so. Within the last month I have started a new Turbine water-wheel of about 350 H. P. The crown gear 7 ft. dia., and jack gear 4 ft. dia. The teeth in these gears are paral-

lel below the pitch line, and when started they did not run smoothly. I had them ground together with tallow and emery, and they at once commenced forming a tooth similar to the epicycloidal tooth.

"In discussing the properties of gears, I have come to the following conclusion. First, That the loss by transmitting power through gears is $1\frac{1}{2}$ per cent. in the driver, $1\frac{1}{2}$ per cent. in the driven, and $1\frac{1}{2}$ per cent. in the teeth, in all $4\frac{1}{2}$ per cent.; *i. e.*, when the diameter at the pitch line is eight (8) times that of the *bearing*. If the diameter is only four to one, then the loss is double, or 9 per cent.; *i. e.*, the friction or loss of power is inversely, as the ratio of the diameter of gears to their bearings. In this statement I have not considered the weight of the gears or shaft. In horizontal shafting the *weight* has no effect, as the weight of the gear seldom is equal to the pressure upon the teeth.

"Secondly. If intermediate gears are used in transmitting power, and the three axes are in the same plane, the friction is double, or 9 per cent. in lieu of $4\frac{1}{2}$ per cent. If the driver and driven have different diameters, the opposite sides of the teeth in the intermediate must be of a different shape, *i. e.* made to conform to the different diameters of the driver and driven. Thirdly, for the same reason, the driver cannot admit of two driven gears of different diameters at the same time and run smoothly.

"As the destroying force or concussion is as the square of the velocity, and velocity of contact is to the pitch of teeth, as verse sine to sine. I have therefore adopted, to transmit the greatest amount of power with regard to durability, the following formula for first drivers, and made tables to correspond. Let $d =$ dia. in feet, $p =$ pitch in feet, and H. P. = horse power: then $\frac{d}{(6\sqrt{d}+1)} = p$, and to find the velocity of the periphery in feet, multiply the square root of the diameter by 750 feet, or $750\sqrt{d} = v$, and

$d^2\sqrt{d}\left(\frac{1}{6\sqrt{d}+1}\right)^2 \times 2200 =$ H. P., *i. e.*, if the pitch and velocity are obtained by the above rule, and the breadth is two and a half times the pitch, which I think will be found correct for spurs, and two and one quarter for bevel gears.

"Usually I think the pitch of gears is too large for the diameter to insure good results. An increased pitch on the same diameter will not transmit more power, as the velocity will have to be diminished.

to make it run smoothly. These formulas are intended for the smaller gear, the larger is not to be considered.

"There are advocates for the rolling of gears together, *i. e.*, the teeth can be so formed that one tooth can be made to roll into the other; but I think this can be shown to be theoretically and practically impossible.

Table showing the Diameter, No. of Teeth, Pitch, Velocity, Revolutions and Horse Power of Gears.

Let. *D.* = dia. in ft. *T.* = No. teeth. *P.* = pitch in inches. *V.* = velocity of periphery in ft., and *H. P.* = horse power.

Dia. in Feet.	No. of Teeth.	Pitch in inches.	Velocity of Periphery in ft. per min.	Revolutions per min	Horse Power.
1	22	1 72+	750	238·8	44
1½	26	2·15	915	194·7	86
2	30	2·53+	1057	168·3	137
2½	33	2 86+	1187	151·1	197
3	36	3·16+	1299	137·8	263
3½	38	3·43+	1403	127·5	337
4	41	3·69+	1500	119·3	414
4½	43	3·93+	1591	112 5	499
5	45	4·16+	1677	106 7	590
5½	47	4·38+	1759	101·7	682
6	49	4·59+	1837	97·4	783
6½	51	4·74+	1912	92 6	993
7	53	4·98+	1984	90·2	1004
7½	55	5·16+	2053	87·1	1115
8	56	5·34+	2121	84·4	1233
8½	58	5·52+	2186	81·8	1357
9	59	5 68+	2250	79·5	1483
9½	61	5·85+	2311	77·4	1607
10	60	6·01+	2371	75 4	1738
10½	64	6·16+	2430	73·6	1876
11	66	6·31+	2488	71 9	2020
11½	67	6·46+	2543	70·3	2167
12	68	6 61+	2598	68·9	2311
12½	70	6·75+	2651	67·5	2462
13	71	6·89+	2704	66·2	2610
13½	72	7·02+	2755	64 9	2773
14	74	7·16+	2806	63·8	2932
14½	75	7·30+	2856	62·7	3099
15	76	7·44+	2904	61·6	3262
15½	77	7·55+	2953	60·6	3429
16	79	7·68+	3000	59·6	3604

"If gears are firmly sustained and well adjusted, and the teeth actually cut in the epicycloidal form, 33 per cent. can be added to the velocity indicated in the above table. This will increase the horse power in the same ratio.

"*Shafting.*—We will next consider shafting and the transmission of

power through the same, the theory of which, I presnme, is well understood by you all; it is, therefore, only in the adaptation that I may differ with some or all of you.

"Wrought-iron shafting of 1 in. diameter will transmit from 14 to 15 H. P. at 100 revs. per. min. before there is any set twist. You will observe by this that a shaft is seldom twisted off, but is usually broken by jar of gears, or being out of line, or by transverse pressure. A shaft 2 in. dia., 100 revs. will transmit 100 H. P. before twisting, but will frequently be broken with very much less power if out of line; while 1 in. to 2 in. shafting, being flexible, will hardly be influenced by small variations. You will perceive from this that torsion is hardly to be considered in shafting a mill, as it will require larger shafting to prevent springing by transverse pressure than it does for torsion. With prime movers, or wheel shafts, we can afford to pay an extra insurance in loss of power and weight of iron, as there is usually but one or two in the mill, and should any accident occur to these it would cause the stopping of the mill, and the loss might cost the price of a dozen shafts, I have, therefore, taken one-fifteenth ($\frac{1}{15}$) of the twisting weight, or the cube of the diameter, &c., $\frac{d^3 \times R}{100} =$ H. P. For second movers we have the formula $\frac{d^3 \times 2 \times R}{100} =$ H. P. For third movers or mill shafting, $\frac{d^3 \times 3 \times R}{100} =$ H. P.

"In advocating small shafting, I do not pretend that, theoretically, there is any saving of friction in transmitting the same amount of power. It requires the same amount of friction for a 1 in. shaft as it does for a 6 in. shaft, if both are equally strained; as a 6 in. shaft, of course, would run very much slower to transmit the same amount of power, but that in most cases the diameter is larger than is required, as the transverse pressure requires a larger diameter than the torsional, as before stated.

"This led me to consider if there might not be some way devised to meet this difficulty. In most of our mills the bays are about 8 ft., and require shafting of about 2 in. dia. to sustain the lateral pressure of a card or loom belt; yet this same shaft has torsional strength at 150 revs. to run 900 looms before twisting, although it may not be running more than 8 to 10 looms or cards when near the end of the line, while a shaft $\frac{3}{4}$ in. dia. is all that is required to perform that amount of work, if well sustained. To meet the difficulty I have made

a cast-iron rail, so constructed that the hangers slide along the whole length of the line without regard to the beams. By this arrangement there can be as many hangers as are required, one to each pulley, if necessary. The number of bearings do not increase the friction if properly arranged, as it is by this rail. I use this rail for all shafting less than $1\frac{7}{8}$ in. dia., where the bays are 8 ft. I have running two lines 160 ft. each. Each line driving 60 breaker cards and lap bead; its dia. is $1\frac{3}{16}$ in. to $1\frac{5}{16}$ in., and runs 280 revs. per min.; driving pulleys on shafting for cards, 7 in. dia. I have also about 1500 ft. more driving cards and looms; about half of it has run 16 months without any repairs. I would here state shafting might be much smaller but for the difficulty of having it made thoroughly in our workshops. The pulleys must be well balanced and nicely bored, or the set screws or keys will spring the shaft.

"I use this rail in connection with shafting for cards and looms. It is not so necessary for spinning and other machinery, as the machinery on them are a greater distance from each other. I have, in one of the Lawrence Manufacturing Co.'s mills, a shaft $2\frac{3}{16}$ in. dia., running 416 revs. per. min., in common Babbit boxes, driving 14,000 ring spindles, $1\frac{5}{8}$ in. ring; this shaft has run 18 months without any repairs or extra labor whatever. It has no self-oilers, but is oiled once a week with a common oil can, using a mixed oil of two parts sperm and one part Downer's paraffine.

"We have another line of shafting 300 ft. long, $2\frac{5}{8}$ in. dia., running 433 revs. per min., driving 15,000 throstle and mule spindles, with full complement of machinery. This shaft has run about ten months; about one-half of it was not under cover, being exposed to the cold weather of last winter. This line has given no trouble. I have yet to see a shaft less than $2\frac{1}{4}$ in. dia. twisted off, and hope if any one present has they will state the fact and circumstances to the meeting. I have often seen larger ones broken by being out of line, and I think this is one of the strongest arguments in favor of small shafting. I think one-half of the friction and three-fourths of the weight of the shaft can be saved over the old system of small and quick shafting well arranged. One can hardly afford to waste a large amount of power to drive the heavy shafting of a large mill, to prevent an outlay once a year or so of some small accident that *may* possibly occur. And furthermore I claim it is better that a small shaft should break, than hold so firmly, as in case of a large shaft it would do, as to cause injury either to life or machinery, as the case may be.

Self protection is the first law of nature, we are told, hence civil engineers always construct mills with a view that nothing shall give out in the future, no matter what its present cost in material and power, as they know full well their reputation is at stake; and should any of their work need renewing in a year or so, they would be condemned. Furthermore, they construct with the knowledge that inferior capacities may run the machinery, and we all know by experience what and how great those difficulties are.

Horse Power of Shafts,—Speed 100 *revs. per min.*

FIRST MOVERS.		SECOND MOVERS.		THIRD MOVERS.			
Dia.	Horse Power.	Dia.	Horse Power.	Dia.	Horse Power.	Dia.	Horse Power.
3 inch.	27·00	2½ in.	31·25	1 inch.	3·00	3 3-16 in.	97·15
3¼	34·33	2¾	41·59	1 1-16	3·59	3 1-4	102·98
3½	42·87	3	54 00	1 1-8	4·27	3 5-16	109·04
3¾	52·73	3¼	68·86	1 3-16	5·02	3 3-8	115·33
4	64.00	3½	85·74	1 1-4	5·85	3 7-16	121·10
4¼	76·76	3¾	105·46	1 5-16	6·78	3 1-2	128 62
4½	91·12	4	228·00	1 3-8	7·79	3 9-16	135·63
4¾	107 17	4¼	163·52	1 7-16	8·91	3 5-8	142·90
5	125·00	4½	182·24	1 1-2	10·12	3 11-16	150·42
5¼	144·70	4¾	214·34	1 9-16	11·19	3 3-4	158·20
5½	166 37	5	250·00	1 5-8	12·87	3 13-16	166·24
5¾	190·10	5¼	288·40	1 11-16	14 41	3 7-8	174·55
6	216·00	5½	332·74	1 3-4	16·07	3 15-16	183·13
6¼	244·14	5¾	380·20	1 13-16	17·86	4	192·00
6½	274·62	6	432·00	1 7-8	19·77	4 1-16	201·12
6¾	307·54	6¼	488·28	1 15-16	21·81	4 1-8	210·56
7	343·00	6½	549·24	2	24·00	4 3-16	220·28
7¼	381·07	6¾	615·08	2 1-16	26·32	4 1-4	230·29
7½	421·87	7	686·00	2 1-8	28·78	4 5-16	240·60
7¾	465·48	7¼	762·14	2 3-16	31·40	4 3-8	251·22
8	512·00	7½	844·74	2 1-4	34·17	4 7-16	262·14
8¼	561·51	7¾	930·96	2 5-16	37·09	4 1-2	273·27
8½	614·12	8	1024·00	2 3-8	40 18		
8¾	669·92	8¼	1123·02	2 7-16	43·44		
9	729·00	8½	1228·24	2 1-2	46·87		
9¼	791·45	8¾	1339·84	2 9-16	50·47		
9½	857·37	9	1458·00	2 5-8	54·26		
9¾	926·86			2 11-16	58·23		
10	1000 00			2 3-4	62·39		
				2 13-16	66·35		
				2 7-8	71·29		
				2 15-16	76·04		
				3	81·00		
				3 1-16	86·16		
				3 1-8	91·38		

—*Daniel Hussey, Esq., Lowell, Mass, from Proceedings of N. E. Cotton Manufacturer's Association, No.* 10, *April* 19, 1871.

Chemistry, Physics, Technology, etc.

ON THE PRINCIPLES OF GUN CONSTRUCTION.

By Lieut. C. E. Dutton, U. S. Ordnance Corps.

[*Concluded.*]

When the art of manipulating and forging large masses of steel began to develop and give signs of rapid progress, it was hoped by many that the time was near when the gun-maker would be able to avail himself of a metal possessing in the highest degree the qualities he desired to utilize. But the record of steel guns forged from a single ingot, cannot be construed otherwise than as a failure to sustain this expectation. The following list of burst guns, of that construction, is by no means complete, though it comprises all the cases of which I have been able to procure accounts apparently authentic.

This record has been sufficiently varied and extensive to leave no uncertainty as to the proper conclusion to be drawn from it. It is of no moment to say that other guns of similar constructions have endured severe trials: no record can be good enough to wipe out such a list of failures. Herr Krupp has virtually conceded this by abandoning that system, and now builds up all of his large guns by shrinking hoops of steel over a central tube with initial tension. Some of these guns, it will be noticed, were made of puddled steel; and if it be urged that this metal cannot be compared with cast steel, the plea cannot be denied. But they serve to show at least this much—that the tenacity is by no means the only element of strength which the gun needs, for the average tenacity of semi-steel is nearly double that of cast iron, and is rather higher than that of the steel put into guns which have exhibited extreme endurance. Nor can it be urged that the weakness of puddled steel is solely due to the fact that it is a mass of welds; for the breaks in these guns do not follow the welds at all. It is unnecessary to pursue this part of the subject, and we may confine ourselves to the brief statement that puddled steel has incomparably the worst record of any metal ever put into a gun.*

It has been frequently observed by those who employ mechanical

*The hoops furnished by Messrs. Petin et Gaudet for banding the French and Swedish cast iron rifles are made of puddled steel and are highly esteemed. The whole method of treatment in the manufacture of these rings is peculiar, and the resulting metal has a character distinctively its own. It is not intended to include them in the above category.

LIST OF FAILURES OF SOLID FORGED STEEL GUNS.

Kind of Gun.	Calibre.	Weight.	Round at which failure occurred.	Bursting Charge. Powder, lbs.	Shot, lbs.	
America.						
1. Wiard 50 pdr..........	5·″1	5700	9	5	50	Nov. 7, 1861.
2. " "	"	"	10	5	50	Dec. 6, 1861.
3. " "	"	"	1	5	50	Dec. 9, 1861.
Several Wiard 12 pdrs. and guns of other makers have also burst.						
England.						
1. Fletcher 6 pdr., S. B.	3·″62	....	1	4½	6	
2. Morgan's 12 pdr........	3·″12	1550	6	2¼	15	June 27, 1860.
3. Lynall Thomas 7″....	7·″	14500	16	25	175	Extreme proof.
4. Krupp 6 pdr.............	3·″5	1800	2	5	18	Nov. 18, 1861.
5. Mushet's 20 pdr.........	3·″7	2700	132	5	180	Extreme proof.
6. Krupp 7″...............	7·″	....	2	18	110	Jan. 29, 1867.
France.						
Three instances only are known, but the details are not full.						
Belgium.						
Two instances with imperfect details.						
Prussia.						
1—6. Six Krupp 4 pdrs., old pattern, on the Wahrendorff plan, are reported to have burst in action during the Austrian campaign, but details not given.						
7. Krupp 72 pdr............	8·″	14900	....	34½	180	Aug. 8, 1865.
8. Prussian 4 pdr., not Krupp's....................	3·″	1100	130	1¼	10	Sept. 27, 1867. Killing an officer and a gunner.
9. Krupp 72 pdr............	8·″	14800	650	27	180	Jan., 1869.
Italy.						
1. Krupp 72 pdr............	8·″	14800	43	17½	180	
Sweden.						
1. Bessemer steel gun....	5·″2	7200	61	8	56	Aug., 1864.
2. Semi-steel gun.........	4·″8	6500	1	5	44	
Russia.						
1. Krupp 96 pdr............	9¼″	30000	....	40½	270	April, 1864.
2. " "	"	"	56	"	"	June, 1866.
3. " "	"	"	....	"	"	Jan., 1868.
4. " "	"	"	....	"	"	July, '69 On board a frigate, occasioning great loss of life.
5. A rifled muzzle-loading gun.....................	"	....	66	40½	270	These guns were bored from solid blocks furnished by Krupp.
6. Do. do. do.......	8·″	.. ..	109	31	180	
7. " " "	"	....	50	25	180	

tests, that very perceptible differences are manifested in the tenacity of specimens which are intended to be identical in all respects except sectional area, and that the larger the area (*ceteris paribus*) the less the tenacity. The difference, which is marked and unquestionable, seems at present to be anomalous. A parallel fact, and one having possibly a relation to it, is that the larger specimens do not elongate so much as the smaller ones of equal original length. In the case of the large steel rods broken by Mr. Eads, the small specimens elongated very considerably, and endured over 100,000 lbs. per square inch, while the very large ones did not elongate at all (that is to say, did not elongate to that extent which may be called ductile yielding) and broke at strains near 30,000 lbs. per square inch. Is it possible that as we increase the sectional area of a tension rod of steel the ductility and tenacity both diminish? or that the elastic and ultimate limits approach each other? This hypothesis is supported by some recent tests made by the late Lt. Col. Rodman of a large block of steel procured from the Bochum Mining and Manufacturing Company of Westphalia.* There seems to be no satisfactory explanation at present available for this anomaly. It is thought by some that carbon is abstracted in the heating furnace. Others seek to explain it by the effects of slower cooling in large masses. The latter explanation is more tenable. We have been in the habit of associating with extreme tenacity and strength a very finely granular and fibrous fracture. The fracture of a large mass of steel is always coarser than that of a small one. We know, also, that these appearances are profoundly modified by the rate of cooling,† and it is very easy to convert a coarse fracture into a fine one by merely re-heating and cooling rapidly; in other words, by "hardening" or "tempering."‡ It is known, too, that the rate of

* Sample bars were cut from the exterior and interior of the block. The tenacity of the exterior was about 58 000 lbs. and of the interior a little over 53,000 lbs. per square inch. The samples tested were 1·″128 diameter—a standard dimension for all test specimens in the Ordnance department. This is much larger than is employed in Europe. Thus at Woolwich the diameter is ″·625, and sometimes less. In Russia it is about ″.7, and in Sweden ″.25. It is noticeable that Swedish tests are generally very high Steel wire has been known to resist 250,000 lbs. to the square inch, and the strength of wire bolts and cables is well known.

† The slow cooling of the Krupp gun blocks was promoted by throwing them into hot ashes and cinder from the furnaces, after hammering, where they were allowed to remain.

‡ The tenacity of the Firth steel, used in the tubes of the Woolwich guns, varies from 25 to 31 tons per square inch before the oil tempering to which they

cooling alters the relation which the carbon holds to the iron, the manner of which we need not pause to explain.

Yet all the allowance which can properly be made in this way seems insufficient to account fully for the numerous cases of rupture in the solid forged steel guns, and we might postulate as a second and co-operative cause the explanation suggested by Mr. Mallet for the weakness of wrought iron guns forged from a single ingot. In these cases the action of the hammer was evidently confined to the exterior portions, and, instead of condensing the interior of the forging, induced such a state of initial tension that a fissure would open in the axial parts. This is the reverse of those conditions which theory and practice alike indicate as necessary to secure the highest restraining power of the metal. It is safe, therefore, to assert that steel allows of no such simple reasoning as is employed in treating generally of the properties of metals. In passing from the small pieces pulled asunder in the testing machine by a measured stress, to the large blocks used in a gun, there enter some qualifying factors of which the ordinary logic does not take account.

There is one important feature of nearly all the known systems of gun construction which should not be passed over, viz., the principle of "initial tension." This consists of disposing the metal in such a manner that when the gun is at rest the interior portions are in a state of compression, while the exterior ones are in a state of tension. This adds much to the strength of a gun, for it compels the outer portions to sustain more and the inner portions less than they otherwise would sustain in the act of firing. This important feature was first introduced about twenty-five years ago, by the lamented Rodman, and has since become almost universal. It is produced in cast iron by cooling the interior more rapidly than the exterior, by use of a water core. Air is sometimes used, especially in Sweden, and is

are subjected. After the tempering the tenacity varies from 42 to 50 tons. The elastic limit is between 12 and 14 tons before tempering, and between 28 and 32 tons afterwards. Krupp does not temper his tubes, but the Russians do. The tenacity of Krupp's steel may be reckoned about the same as Firth's; The enormous tenacity sometimes assigned to Krupp's steel is apt to mislead the ill informed: it gives the same results as other steels of the same constitution, when tested in the same way. The quantity of carbon best suited to these tubes is ½ per cent. This is Krupp's and the Russian standard, and I believe also Firth's, but Krupp's, steel contains a notable percentage of silicon, amounting in some analyses to ·44 of one per cent., an amount which is generally considered to be decidedly injurious.

necessary with the Swedish iron, which appears to contract more in cooling than our American gun irons. From some unexplained cause, irons smelted from magnetites contract more than those from limonites, and hence the water core becomes necessary, to secure the proper amount of tension, in our guns,* which are made from limonite irons. We gauge the amount of tension by cutting off a ring from the muzzle while in the lathe. This ring is planed through by a radial cut, and springs asunder when the tool is nearly through, showing a tendency to unroll. By measuring the amount of gape, we have a comparative notion of the amount of tension. In built-up guns the successive cylindrical layers are shrunk on hot, while the barrel itself is cool. Generally, when the gun consists of several layers, the amount of tension given to each layer increases from the tube outwards, the outer layer being strained very considerably. Subsequent firing, it is believed, always tends to relieve gradually this tension, by stretching the metal permanently, and this is one cause of the diminished strength of guns after protracted service. But let us proceed now to glance briefly at the prominent systems of gun construction in various foreign countries, and witness the applications of these ideas.

The system of gun construction adopted in England is the so-called Woolwich system. In a general way, it may be called a modified form of the Armstrong system, which consists in surrounding a central steel tube with wrought iron coils. The modifications are highly important. The Armstrong gun, as now built at the Elswick factories, near Newcastle, consists of a steel tube, with a heavy jacket of longitudinal bars welded together, inclosing the rear end. The remainder of the tube and the jacket are surrounded by numerous coils, shrunk on and "hooked" together. The Woolwich gun dispenses with the jacket of longitudinal bars, and reduces the number of coils to a minimum, *i. e.*, two or three large coils, instead of numerous smaller ones. This reduction of number is a great improvement on the score of economy, and appears to involve no sacrifice of strength. But the chief point of difference is the elimination of the jacket of longitudinal bars. This was, of course, designed to give longitudinal strength; but this great axial strength is, in the first place, excessive, and, in the second place, is obtained by the sacrifice

* The Parrott guns, on the contrary, are from magnetite irons, and the great inequality in their endurance was thought by Rodman to be attributable to this cause.

of circumferential strength at the very locality where the wrought iron part of the gun should possess the most of it. As is well known, the strength of an iron bar, in a direction perpendicular to its length, is very much less than the longitudinal strength; the welds, also, are planes of weakness in the jacket. The Woolwich gun, very properly, does away with this, and is apparently a stronger construction. The English constructors have a pious hatred of both steel and cast iron, on account of what they term their "treacherous" character, and maintain that they use steel in the bore, not for its strength, but for its hardness and freedom from welds, which are necessary in coils. They depend upon the coils for the restraint against bursting, and consider the steel tube a mere lining, charging upon the tube all failures. On the other hand, the opponents of the Woolwich construction say that it is weak, because the soft wrought iron, with an inferior elasticity, relaxes its grip on the central tube after a few fires, giving it very little support, and compelling it to sustain, almost unaided, the stress of firing. But experience seems to sustain neither view completely. It can be shown, I think, that the Woolwich people very much underrate the efficiency of the steel tube, and somewhat overrate the efficiency of the coils, while their adversaries as obviously are guilty of the reverse error. If either party could prove its position, it would prove what is not a fact, viz., that the Woolwich gun is a very bad gun. In their eagerness to condemn steel, and to glorify wrought iron, the Woolwich constructors have thrown a boomerang, and their opponents have answered by firing at random. These are the impressions produced upon an unprejudiced observer, who has carefully studied the records, so far as they could be learned.

To undertake to give even a condensed summary of the record of the present Woolwich construction is a serious task. That record has been a long, uncompromising, severe one. No system of construction has ever been tested so severely, and hence it is difficult, if not impossible, to institute a comparison between it and any other record. We may, for purposes of discussion, divide the Woolwich guns into two classes with respect to calibre: 1st, guns of 9 inches and smaller calibres; 2d, guns larger than 9 inches. The record of the first class has been emphatically good. It is not entirely unblemished, but, on the whole, it represents so much triumphant success, and so little disaster, that any attempt to impeach it looks like captious criticism. These guns have, in many instances, endured over 1000 rounds with heavy charges; a still greater number have endured over 500 rounds. A few guns have exhibited inferior endurance, but they represent, in

nearly every case, the earlier stages of the present construction. One instance occurred where a 9-inch gun burst explosively at the first proof round; but it may be fairly argued that a gun belonging to an established system of construction is not a candidate for a record, as a part of the system, until after it has passed the regulation proof. The results of a regulation proof must be held to be applicable, not to the system, but tc the particular gun under proof. Respecting guns over 9 inches calibre, the record is not so clear. One 10-inch gun has fired over 400 rounds without injury, but no guns of the latest Woolwich construction, of largest calibres, have been put to extreme proof. The new 35-ton gun appears to have exhibited signs of weakness prematurely, and the present indecisive stage of the record, as far as it goes, points to the conclusion that the Woolwich system displays its highest efficiency in guns not exceeding 9 or possibly 10 inches calibre. No 12-inch English gun has survived 270 rounds.

The system adopted by Russia and Prussia is the new Krupp construction. It consists of a very heavy central tube of steel, surrounded by successive series of steel hoops, shrunk on with powerful initial tension. This construction contrasts strongly with the old, and, on principle, is a great improvement. The hoops are rolled in a tire-mill, and being necessarily very short, can exercise only a circumferential resistance. The longitudinal strength is abundantly supplied by the central tube, which projects far enough to the rear to accommodate the breech closure (or fermeture). The only question which can be raised is respecting the central tube. This is very massive—almost a gun by itself—and is forged from a large ingot, which loses half its weight in the lathe. May there not be in this tube a remnant of the weakness found in the old solid forged guns? The restraint of the hoops may be expected, however, to counteract any such weakness, if it should be proved to exist, but not completely. The strength of the metal in the hoops is higher than that of the tube, which may be attributed to the widely different manner of working up the scantling, as well as to its smaller size and different mode of cooling.* There is, therefore, an excess of strength in the hoops, and if a modern Krupp gun should be disabled, we might anticipate that the failure would occur in the tube.

The objection raised against an all-steel gun by the English con-

* Tires are cooled by a jet of water playing on them, after they have been rolled to gauge and before they are removed from the machine. Besides preventing distortion, this actually increases both the strength and hardness of the tire.

structors is, that this metal is treacherous. We have seen, in the cases of solid steel guns, that there is much reason for this belief; but in the built-up guns the record shows no such thing. To explain the failures in the former guns, we are obliged to resort to what are, at best, merely probable hypotheses, and yet, by the light of subsequent experience, so probable that we are justified in assuming their correctness in the absence of any better ones. There is nothing in the past to throw doubt on the assumption that, if we can insure the presence of proper tensions, the absence of adverse tensions, and avoid the interference of vibratory waves, steel is as safe a metal as wrought iron. All of these adverse conditions are aggravated as we increase the masses exposed to them, and the method of building up the gun is a safeguard against disaster from either of these causes. The initial tension from the wrong direction is obviated, and that from the right direction secured by it; and the contact of surfaces of successive layers, having small or moderate thickness, prevents the propagation of dangerous vibrations. The record of the new Krupp guns abundantly sustains these views. The only failure is that of an 11-inch gun, at Cronstadt, which blew into fragments the front part of the tube forming the chase, at the eighth round—the body of the gun and its hoops remaining on the carriage, otherwise uninjured. The circumstances of this mishap were peculiar. It appears that the shell broke up in the gun, and it is believed to have wedged in the chase. The accumulation of pressure thus produced, together with the *vis viva* of the gases suddenly checked, are believed to have caused the rupture. It is of course impossible to prove the correctness or the incorrectness of this explanation. There is nothing intrinsically improbable in it, notwithstanding the fact, that in a vast majority of cases where projectiles are broken in the gun, nothing more than a trifling local injury is produced, or even no injury at all. On the whole, it seems proper to give the gun the benefit of the doubt, and consider this failure as not indicative of any special weakness, but the result of a mishap, which can seldom occur in so disastrous a manner. And yet there is a lingering suspicion that these heavy steel tubes inherit a trace of the weakness shown by their predecessors, the solid forged guns; but we will hope otherwise. Assuming that this instance proves nothing and unsettles nothing, let us look at the remainder of the record of the Krupp guns.

1. The first trial gun has fired 410 rounds without injury; the calibre was 11 inches.

2. Another 11-inch gun has fired about 1080 rounds without injury.*

3. A 9-inch Krupp gun (228.6 millimeters) has fired 712 rounds at Berlin. A small crack appeared in the chamber after the 662d round, which enlarged somewhat during 14 subsequent rounds, but did not increase during the last 36 rounds.

4. A similar gun has fired 825 rounds without any material injury.

5. Another 9-inch gun has fired 400 rounds without injury.

6. An 8-inch Aboukoff † gun has fired 1300 rounds without material injury.

7. A 9-inch Krupp gun has fired in Austria 650 rounds, and is still serviceable.

8—9. Two 8 inch guns, constructed on Krupp's plan, by the Bochum Company,‡ have each fired upwards of 500 rounds, and are serviceable.

A considerable number of 6-inch siege guns (Krupp's) have fired more than 1000 rounds each during the late war, and no failures are reported.

In justice to other systems, it should be stated that these large Krupp guns have been fired almost always with the prismatic powder, which is exceedingly mild in its action,§ while the Woolwich 9-inch guns have fired a powder of very violent character. It might also be stated that even cast iron guns have shown extraordinary endurance. Some of those used at Paris seemed to do about as well as Krupp's, and it is reported that an 11-inch Swedish rifle has fired 1100 rounds. But notwithstanding this, the record of the Krupp system of hooped guns is, so far, a triumphant one, and though it may be impossible to institute an exact comparison with other systems, it is safe to pronounce it eminently successful.

It may be of interest to compare the Krupp construction with that of Mr. J. Vavasseur, of the London Ordnance Works. The Vavasseur gun consists of a steel tube, with hoops of the same metal. The tube, however, is much thinner than Krupp's, and is jacketed from the

* It is barely possible that these two 11-inch guns are one and the same, though I think otherwise. This record has been a difficult one to procure, though for the most part it is founded on the best authority.

† The Russian government constructs guns essentially on the Krupp plan at the Aboukoff works, near St. Petersburg.

‡ This information was given me verbally by a reliable informant.

§ The highest recorded pressures in the 11-inch trial gun were about 66,000 pounds, and the average about 46,000 pounds per square inch, which is a very low average for a gun of that size. The diameters of the cartridges are considerably smaller than those of the chambers, which greatly relieves the pressure.

breech to a short space beyond the trunnions, with a second tube shrunk upon it—the hoops encircling the jacket. The unjacketed part of the tube is also hooped clear to the muzzle. In this gun the strength is cast more upon the hoops, and less on the tube, than in Krupp's, and the initial tension is more effectually carried out. Mr. Vavasseur's gun is certainly worthy of more attention than has been bestowed upon it.

The construction adopted by the French, Belgian, Dutch, Danish and Swedish governments for large rifles, is cast-iron hooped with steel. This manner of building a gun is not to be commended. It involves a fallacy. A gun all cast-iron would be rather stronger than one of equal dimensions with steel hoops, because the cast-iron in the exterior, for a given amount of stretch, would exercise a greater amount of restraint than the steel. The ultimate tenacity of the metal has nothing whatever to do with this case, because in any event the degree of strain upon the outer portions is far below the useful limit of strength of good cast-iron, and much more so of steel. It is solely a question of extensibility. The less extensible the metal is, under a given stress, in the outer parts, the greater is the force required to give it a certain amount of stretch. As this elastic force measures the amount of restraint exercised, it follows that the less elastic metal will exercise more restraint in the exterior. Let us illustrate this. Take a French gun turned down ready to receive its hoops. In the act of firing, the metal is stretched, we will say, to such an extent that the circumference of the breach is increased a tenth of an inch. Now let us add another layer of metal—if you choose, with initial tension. When the gun is fired this ring must also stretch a tenth of an inch. In order to stretch our cast-iron the tenth of an inch in ten feet, we must have a tensile strain of 13,000 pounds per square inch. But to stretch a steel hoop a tenth of an inch, we need a stress of only 8800 pounds per square inch; in other words the cast-iron would exercise more restraint than steel in the ratio of 13 to 8.8. There is one condition in which steel would have the advantage. If the initial tension were so great that the cast-iron in the exterior were near its safe limit, then it might be ruptured on the outside, owing to the inferior strength of cast-iron. But practically this never happens in a properly cast gun, and in this country we always take special pains to keep the initial tension of our guns within safe limits.*

* Notwithstanding every precaution, we have lost a number of guns by over-tension, although but one known case has occurred in which such a gun has been accepted.

The use of two kinds of metal in construction is illustrated very well in the methods of Maj. Palliser and Mr. Parsons, for converting cast-iron smooth-bores into rifles by lining them. Maj. Palliser's method consists in introducing a wrought iron tube, made by welding a coil endwise. It is inserted at the muzzle, and held in place by a washer screwed into the muzzle a few inches, and abutting against a shoulder, or rebate, in the front end of the tube. As this mode of conversion is intended only for a special purpose, it should be criticised only with reference to its suitableness to that purpose. It is designed merely as a mode for converting into rifles the 68 pounders and smaller smooth-bores, which are scattered thickly over the world-wide dependencies of Great Britain, in situations whose military importance renders the use of the larger and more costly Woolwich guns unnecessary, or at present unadvisable. They are not regarded as being adequate to inflict damage upon the more heavily armored vessels of the day, and are chiefly located where such a vessel could never go. The vast number of such guns called for a cheap and speedy mode of conversion, and Maj. Palliser's plan seemed to meet the requirements. Three or four thousand guns have been converted in this way, and their performance is regarded by the English as satisfactory.

Mr. Parson's plan consists in introducing a steel tube with a jacket of steel through the breech of the gun, which is cut away for the purpose, and after the tube is inserted the breech is stopped up by a large cascable screwed in. This is a much stronger way of lining a gun than Maj. Palliser's, but it is also much more costly, and the great expense of converting on this plan, coupled with the constitutional distrust of steel and cast-iron inherent in the British ordnance mind, led to its rejection. But the Parson's gun is a most excellent one. The objection to it is that it is too costly to answer for a converted gun, and the fact that it is a converted gun prejudices it* in competition with original constructions.

You would not consider this lecture complete without a statement of the position of the American Ordnance Department, and the character of its material. In speaking on this point, I must disclaim the idea of offering you anything more than the views of an individual, committing no body unless it be himself; and in consideration of the difficulty of the subject, the extreme liability to error, and the wide diversity of opinion the world all over, on the various questions con-

* This prejudice is probably unjust, but none the less real.

nected with the ordnance problem, he hopes he is not committing himself irrevocably.

The United States Ordnance Department is generally regarded as advocating for heavy armament an exclusive system of cast-iron smooth bores. This is not true; it is indeed the reverse of truth. That department has long advocated the use of heavy rifles, and has not the slightest intention to make them of cast iron, unless in our present defenceless condition a war should be suddenly sprung upon us, in which case the question would resolve itself into a choice between cast-iron rifles or none at all. To set this matter on a proper basis, let us look at the plan of armament decided upon for the future, and see what those views are. In January, 1867, a board of officers of high rank, consisting of two from the engineers, two from the ordnance, and two from the artillery, was convened at Washington, at the instigation of the Ordnance Department, to determine the calibres, the number of each calibre, and the proportion of rifled guns for the armament of fortifications. It was unanimously recommended by this board "that the calibres of the heavy ordnance hereafter to be provided for the armament of permanent fortifications should be: For smooth bore guns, 20-inch, 15-inch and 13-inch; for mortars, 15-inch and 13-inch; for rifles, 12-inch and 10-inch; and that guns of other than the above calibres, now on hand, be used in the positions for which they may be most suitable, or in their present positions, until they can be replaced by guns of the calibres above specified." The guns for the defence of New York harbor were also specified, giving the numbers for every fort, and of these a majority were 10-inch and 12-inch rifles.

In January, 1868, an Ordnance Board convened at Washington, and from their report I extract the following: "The Board recognizes the following as the standard calibres of ordnance for land service:

Small arms.

Breech-loading musket calibre, ...	″·50
Revolving pistol, ...	″·44
Breech-loading carbine, ...	″·50

Field guns.

3-inch and 3·5-inch rifle (wrought-iron).
4·62-inch (12 pds.), smooth bore (bronze).
4·62-inch (12 pds.) mountain howitzers (bronze).
1-inch and ·5-inch Gatling guns (on trial).

*Siege guns.**

4·5-inch rifle, ...	cast-iron.
8-inch howitzer, ...	"
8-inch mortar, ...	"
10-inch mortar, ...	"
5·82-inch (24 pdr.) Coehorn mortar. . . .	bronze.

Sea-coast guns.

10-inch rifle, ...	cast-iron.
12-inch rifle, ...	"
13-inch smooth bore, ...	"
15-inch "	"
20-inch "	"
13-inch mortar, ...	"
15-inch "	"

"The Board recommends, however, that the following calibres be retained in service until replaced by the above:

Springfield musket calibre ″58.

3″., 4″·2, 6″.4, 8″ and 10″ Parrott rifles.

5″·82 and 6″·4 bronze howitzers.

6″·4 and 7″ cast-iron banded rifles.

8″ and 10″ smooth bore."

It is true that the large guns recommended by this board were specified as cast-iron guns; but the views of the officers composing it were expressed as follows:

"The success of the experiments with the 12-inch cast-iron rifle at Fort Monroe evidently demonstrates that further trials with cast-iron should be made, and as it is possible that other systems of construction and other kinds of material may give better results, the Board would earnestly recommend the following additional guns to be fabricated and fully tried, viz., one 12-inch cast-iron rifle, lined with steel, and one 10-inch cast-iron rifle, lined with steel. While recognizing the superior strength of steel and wrought-iron over cast-iron, yet, owing to the difficulties experienced in working either of these metals in large masses, in the present state of the arts, and of the still greater difficulty of bringing the metal in large guns, made wholly of either of these materials, into the best condition for resisting the enormous strains to which they are subjected, the Board is of the opinion that it would not be judicious to make trials of these metals in the heavy guns, which

* To the list of siege guns will probably be added, at some future time, a 7-inch rifled gun.

the present construction of vessels of war renders absolutely necessary, until after the results of the experiments herein recommended shall be known, and the state of the arts shall warrant the belief that better guns of large calibres can be made safely of steel and wrought-iron."

If we take into consideration the state of the ordnance problem at the time this opinion was enunciated (Jan., 1868), it will appear to be thoroughly justified. It may have been a singular coincidence, but it so happens that, of the records before that board, the record of cast iron was by far the best. Of all the Rodman smooth-bore guns which had been put to proof, not one had failed, though two ten-inch guns had fired upwards of 4000 rounds, and one fifteen-inch gun upwards of 350, with its proof still in progress. A twelve-inch cast iron Rodman rifle had endured upwards of 400 rounds, and was entirely uninjured. A ten-inch cast iron rifle had endured more than 1000 rounds, failing at the 1047th fire, and the proof of another eight-inch rifle was in progress. On the other hand, the record of the European systems was far from satisfactory. The Krupp solid-forged guns had failed, and the hooped guns had not been tried. The Armstrong guns of large calibre had merely a tolerable record, and I believe that up to this day no English twelve-inch gun has survived 266 rounds. Surely the Board could not have decided otherwise than they did. But a few months changed the aspect of affairs. It was in 1868 that an eleven-inch Krupp gun of the new construction passed a satisfactory proof, and two nine-inch Woolwich guns endured more than 1000 rounds each. On the other hand, our twelve-inch cast iron rifle burst at the 472d round, and an eight-inch rifle at the 80th. Last September, a second twelve-inch rifle burst, at Ft. Monroe, at the 27th fire, and I presume it will generally be considered that those failures settle the question whether cast iron can be safely used for large rifles. The last report of the Chief of Ordnance states that the results attained with this metal are not such as justify confidence in its use for large rifles, and recommends an appropriation to construct and prove a twelve-inch rifle on Dr. Woodbridge's plan, the details of which the inventor objects to making public just at present. The project holds out some promise of feasibility and is in its principal feature a novelty. But as to its ultimate success all surmises are useless. The experiment was recommended by the lamented Rodman, and is regarded by our Ordnance officers with much interest. A small gun has been successfully made on this plan, and has endured an extraordinary proof. But, although much is hoped for, nothing is definitely anticipated.

It appears, then, that our system of heavy ordnance is at present a paper system, and not a reality. It contemplates both smooth bores and rifles of very great calibre. That the smooth bores will be made of cast iron there is little doubt; but the rifles I anticipate will be made of steel. The guns which occupy our parapets are the relics of the recent war, excepting a few fifteen-inch guns. Only two twenty-inch guns have been made, and only two thirteen-inch, and of the latter, one expired after a very creditable endurance. Three twelve-inch rifles have been constructed, two of which have burst, one of them very prematurely.

Since the year 1867 no guns have been constructed for our armament, and only a few for experiment. The reason has been the refusal of Congress to appropriate for this purpose. The all-absorbing spirit of economy has controlled legislation in this regard, and as ordnance experiments are looked upon as a kind of exaggerated boys' play, they have been treated as superfluous luxuries. Another obstacle has been the unscrupulous assaults upon the Ordnance Department by unprincipled adventurers, who have employed the darkest resources known to the lobby to overthrow the Department, because it refused to adopt their inventions without reserve. But we hope that the repeated representations which have been urged upon the proper committees concerning the want of a new armament will have their effect at last, and that before long we shall commence in earnest the work before us. It is time that we made a beginning. Ten years ago our guns were the most powerful in the world, but since then we have remained stationary, and the nations of Europe have gone past us, and are nearly out of our sight.

ON A NEW MODIFICATION OF THE HOLTZ MACHINE.

By C. Van Brunt.

(Communicated by Prof. Henry Morton, Steven's Institute of Technology.)

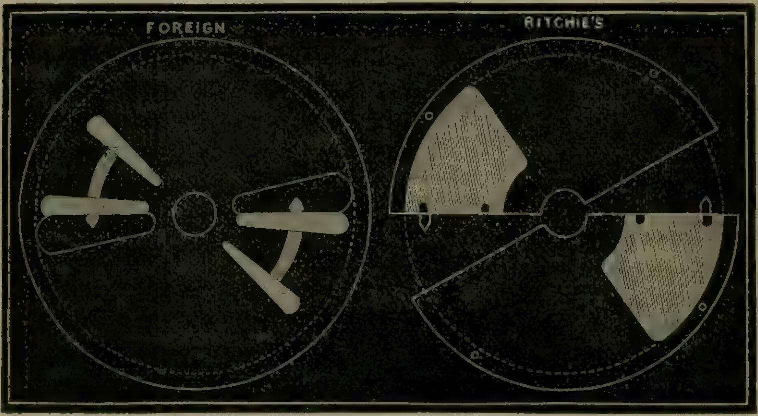
A 16-inch Holtz machine was purchased of Mr. Ritchie and taken to Vassar College; the building was heated by steam. The machine could not be started, and it was brought to my rooms, where, having a large electrical machine in use, I could very readily make it work. Upon receiving the machine, I commenced a series of systematic experiments, and the result I wish to describe.

The latest form of the Holtz machine, as imported, has two "windows" in the back plate, instead of four; a skeleton paper arrangement, with points and a comb crossing in front of the revolving plate,

Mr. Richie imitates by two sectors, and uses continuous paper pieces.

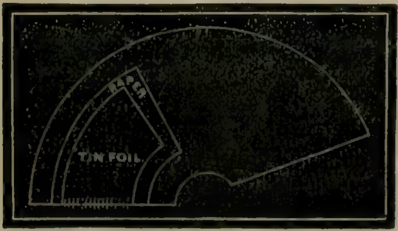
The following are the results of my experiments:

First, I discovered that the action of the machine was much improved by making a *series* of paper points instead of one point; that short points were as good as long ones; that paper in the Ritchie form



was better than the skeleton form; that a good conducting paper was better than a poor one, and thence I was led to the use of tinfoil instead of paper, or rather with paper, using paper, however, only as an insulator. In connection with this, I also ascertained that the form of the hole is of no consequence, a few holes through the glass, a slit, or large holes, as in the foreign machine or Ritchie sectors, answering the same purpose.

The following directions will explain my method of attaching to the Ritchie sectors. I show *one* in the sketch below; they are both alike.



Place a piece of paper on the sector just as Ritchie does in his machine at an angel of about 50 to 60°, and about the width of the collecting points, the outer edge uniform with the edge of the revolving glass, or use his paper if it meets these requirements: put no paper over the edge of the sector, or remove it if it is there. Then attach to the paper along the edge of the sector a row of pins a half inch long, *common pins*, on the paper in which they are sold, the row one inch less in length than the paper on the sector is wide, in this way—cut off a row, leaving a little paper on

each side of the row, turn the paper under the points, backward, and put in a little wedge of card-board; this will make the pins *cant* towards the revolving plate over the edge of the sector; gum it all securely fast. Then paste on the surface of the paper on the sector a piece of tin-foil, of smaller size, leaving a uniform margin of half an inch of paper all around it, except that it should extend to and connect with the heads of the pins. It is now all complete except insulating.

Paste a slip of paper all round the foil and over it half an inch, the strip about an inch wide, and well shellac the surface of the strip and the outside edge. No shellac is needed under the foil or anywhere except outside on the paper strip and its outer edge.

This arrangement makes a perfect conductor to the foil, from the revolving plate, and puts the foil in an insulated pocket, the paper tapering off the tension, as when used around the inside top of a Leyden jar.

The machine, arranged in this way, will jump at once into activity, and produce a torrent of electric discharge. If well shellaced around the edge of the paper it will not reverse or lose its tension, but the sparks will pass certainly to a distance equal to one half the diameter of the revolving plate and perhaps more.

A large Leyden jar, (one to two gallons,) well made, attached to the negative side in place of the small phial, will increase the length, brightness and sound of the spark, and the machine will retain its charge twenty-four hours, and perhaps longer, in ordinary winter atmosphere. This acts as a large and small ball for passage of sparks on an ordinary electrical machine. There is no danger of breaking the large jar, for the small phial acts as a unit jar, the strain is thrown on the phial; this should be protected by a cork the size of the phial, covered with tin-foil pushed down to the inner coating, for the conducting rod to rest upon; the strain is thus distributed. The upper edge of the coatings of the phials should be covered with strips of paper and shellac, to prevent spontaneous discharge.

With this new arrangement of the machine the ordinary phials are sure to break.

The electricity can be reversed at pleasure, by pushing the balls together after it has made or is making long sparks, stopping the machine, then separating the balls half an inch, putting the comb directly across the papers, then turning, and at the same time moving the comb back to its normal position. The sparks will then pass rapidly, and the poles be reversed.

It will sometimes reverse after it is driven at its utmost tension, by pushing in the balls without touching the comb, and if the comb is left too near the foil or paper, it may reverse, after long sparks, of its own accord. The proper place for the comb is an inch or so beyond the paper, over the clear glass. The better the foil is insulated, the less inclination it has to reverse. With foil on the glass without insulation it will not make over a two-inch spark without reversing.

With the arrangement as described the machine runs with little friction—but little of the hissing or frying sound—makes less ozone, and is evidently near perfection.

From some of the experiments, I am led to believe an entire modification of the parts will still further improve it; but this is so great an improvement, with so little cost and trouble, that I deemed it worthy of a description.

CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

(Continued from page 144.)

History of the Stereoscope.

After the full consideration, in the previous pages, of the nature of the pictures which constitute a stereograph, and the manner of producing them, as well as the ocular methods of combining them, it will now be comparatively easy to explain the part that the various instruments, called stereoscopes, play in assisting to overcome the difficulty which, to a greater or less degree, is encountered by every one in attempting to combine the pictures, by any of the ocular methods, so as to obtain the surprising appearance of relief, which our experience leads us to expect only from real objects.

Natural as the preceding methods of combination may appear, and easy as they may prove to most individuals after a short trial, their use seems to have followed rather than to have preceded the invention of the stereoscope. They have been discussed, first, simply because they are best adapted to the statement and elucidation of the fundamental conception involved in the invention of that instrument; the devising of an instrument being indeed a second, and more readily suggested step.

The credit undeniably belongs to Professor Wheatstone for having originated that conception, and of having practically demonstrated its truthfulness. He placed the whole subject of Binocular Vision before the scientific world in a new light by his paper, read before the Royal Society, June 21st, 1838, and subsequently before the British Asso-

ciation, in August of the same year, and by the exhibition, at the same time, of an instrument which he called "a stereoscope, from its property of presenting to the mind the perfect resemblances of solid objects. To understand the principles on which it was constructed, he explained the circumstances which enable us to distinguish an object in relief from its representation on a plane surface." * * * "He next showed that if the object were thus drawn first as it appears to the right eye, and then as it appears to the left eye, and those two pictures be presented one to each retina, in such a manner that they fall on the parts as the projections from the object itself would, the mind perceives a form in relief, which is the perfect counterpart of the object from which the drawings have been taken; the illusion is so perfect that no effort of the imagination can induce the observer to suppose it to be a picture on a plane surface."*

This contribution of Professor Wheatstone's was noticed in the the prominent scientific journals of the day, and the surprise and delight with which it was received in scientific circles sufficiently substantiates its character for novelty. No one was more competent than Sir David Brewster to appreciate it fully, and no one seemed more surprised and gratified, according to the following statement of the proceedings of the Association:† "Sir D. Brewster feared that the members could scarcely judge from the very brief and modest account given by Prof. W. of the principle, and of the instrument devised for illustrating it, of its extreme beauty and generality. He considered it one of the most valuable optical papers which had been presented to the Section. He observed that, when taken in conjunction with the law of visible direction in monocular vision, it explains all those phenomena of vision by which philosophers had been so long perplexed; and that vision in three dimensions received the most complete explanation from Prof. W.'s researches. Sir J. Herschel characterized Prof. W.'s discovery as one of the most curious and beautiful for its simplicity in the entire range of experimental optics."

After the instrument proposed by Prof. Wheatstone had been generally superseded by the lenticular stereoscope, subsequently devised by Sir David Brewster, great efforts were made by the latter and his friends to reduce the claim of Prof. Wheatstone to the simple invention of *a* stereoscope, and that not a very convenient one.

The case can be best stated, and the claims of Prof. Wheatstone, together with the prime fact in the discovery, be set forth by a *resumé*

* Eighth Report of British Association, 1838 (or Vol. vii), notices, &c., p. 16.

† Silliman's American Journal of Science, Vol. xxxv, 1839.

of the historical argument of Sir David against them, without noticing, however, such statements as seem, to the regret of the friends of the latter savant, simply to manifest a spirit of unfairness, and at times incivility towards Prof. Wheatstone.

The fact that the eyes must necessarily receive dissimilar impressions from external objects was one that was noticed at a very early period, and frequently commented upon. Thus Euclid, more than two thousand years ago, demonstrated "that the part of a sphere seen by both eyes, and having its diameter equal to, or greater or less than, the distance between the eyes, is equal to, and greater or less than, a hemisphere." The celebrated physician Galen, more than fifteen hundred years ago, discussed the subject more fully, and enunciated the fact more clearly. The propositions of Euclid were repeated, and passages from Galen quoted by Baptista Porta in his work on Optics, published in 1593, at Naples. In illustrating the views of Galen, he employed a figure which Sir David considered "a much more distinct diagram than that given by the Greek physician," and remarks :* "In looking at this diagram we recognize at once not only the principle but the construction of the stereoscope," and states that a "double stereoscopic picture or slide is represented" by the figure, and thereupon that "Galen, therefore, and the Neapolitan philosopher, who has employed a more distinct diagram, certainly knew and adopted the fundamental principle of the stereoscope; and nothing more was required, for producing pictures in full relief, than a simple instrument for uniting the right- and left-hand dissimilar pictures of the column."

It is not necessary to reproduce the figure alluded to in order to dispose of this argument; for, although it might seem reasonable to allow that Porta may possibly have had some vague notion in regard to the fundamental principle underlying the invention of the stereoscope, although he took no steps to give it a practical demonstration, the following statement, previously made by Sir David,† not only shows that the principle of the stereoscope had not suggested itself, but was inconsistent with his explanation of the phenomenon of distinct vision with two eyes: "Believing that we see only with one eye at a time, he denies the accuracy of Euclid's theorems, and while he admits the correctness of the observations of Galen, he endeavors to explain them on other principles." The explanation of Porta, however, although it will not answer for the distinctive effects of binocular vision, as they have been set forth, is not necessarily to be

* The Stereoscope, p. 9.

† Id., page 8.

considered altogether absurd. In some cases doubtless more, if not exclusive attention, is paid to the impression made upon one eye. It is also still met with occasionally in the same connection. Thus it is reproduced by Dr. Lardner in his popular treatise on Natural Philosophy.* In explaining why, having two eyes, we do not see double, he remarks: "If the two eyes convey to the mind precisely the same impression of the same external object, differing in no respect whatever, then they will produce in the mind precisely the same perception of the object; and as it is impossible to imagine two perceptions to exist in the mind of the same external object which are precisely the same in all respects, it would involve a contradiction in terms to suppose that, in such a case, we perceive the object double. If to perceive the object double means anything, it means that the mind has two perceptions of the same object, distinct and different from each other in some respect. Now, if this distinctness or difference exists in the mind, a corresponding distinctness and difference must exist in the impression produced of the external object on the organs. It will presently appear that cases do occur in which the organs are, in fact, differently impressed by the same external object; and it will also appear that in such cases precisely we do *see double*." After a full discussion of the subject, in which he takes the moon as the representative of a distant object, he concludes: "Consequently it follows, demonstratively, that all objects which are placed at a distance compared with which the distance between the eyes is insignificant, will convey a single perception to the mind, and will consequently not be seen double." He then, however, discusses the case of such objects as do practically come within the range of the binocular parallax, in a new section, as follows: "*Exceptional cases in which objects are seen double.* * * Let us suppose an object placed so near the eyes that its distance shall not bear a considerable proportion to the length of the line which separates the centres of the eyes. In this case, the images produced on the retina of the two eyes may differ in magnitude, and intensity of illumination, and even in form, and, in fine, it is clear that the apparent direction of any point on the object as seen by the two eyes will be sensibly different. In this case, therefore, the two eyes convey to the mind a different impression of the same object; and we may therefore expect that we should see it double, and in fact we do so. But the observation of this particular phenomenon requires

* Hand-Books of Nat. Philosophy, 1st course, Philada., 1851, p. 174.

much attention, inasmuch as the perception of which we are conscious is affected not merely by the impression made upon the organ of sense, but by the degrees of attention which the mind gives to it. Thus, if the two eyes be differently impressed either by the same or by different objects placed before them, the mind may give its attention so exclusively to either impression as to lose all consciousness of the other."

Distinct reference is, however, undoubtedly made by Leonardo da Vinci, 1584, not only to the dissimilarity of the pictures seen by each eye, but to a consequent *relievo* in the impression of an object obtained by two eyes that is inimitable in "a painting, though conducted with the greatest art and finished to the last perfection, both with regard to its contours, its lights, its shadows, and its colors."

Considerable attention is paid by Sir David to the views of a learned Jesuit, Aguilonius, who, in a work on Optics, 1613, "has some difficulty in explaining, and fails to do it, why the two dissimilar pictures of a solid, seen by each eye, do not when united give a confused and imperfect view of it." His whole effort is to explain away the fancied disadvantage of two eyes, without alluding to any advantage the possession of two eyes confers, and finally he introduces "common sense," as reconciling the slight differences of the pictures, and making a single notion.

In his treatise on Optics, Dr. Smith, in discussing this subject and quoting from and commenting upon Leonardo da Vinci, clearly states not only the dissimilarity of the views obtained by the two eyes, but the advantages as follows: "Hence we have one help to distinguish the place of a near object more accurately with both eyes than with one, inasmuch as we see it more detached from other objects beyond it, and more of its own surface, especially if it be roundish."

So, likewise, Mr. Harris, in 1775, with equal clearness sets forth the advantage of the possession of two eyes, as follows: "We have other helps for distinguishing prominences of small parts besides those by which we distinguish distances in general, as their degrees of light and shade, and *the prospect we have around them.*"

The historical argument is closed by Sir David by the question: "What student of perspective is there—master or pupil, male or female—who does not know, as certainly as he knows his alphabet, that the picture of a chair or table, or anything else, drawn from *one point of sight*, or as seen by one eye placed in that point, is *necessarily dissimilar* to another drawing of the same object taken from another point of sight, or as seen by the other eye placed in a point 2½ inches

distant from the first? If such a person is to be found, we might then admit that the dissimilarity of the pictures in each eye was not known to every student of perspective."

It seems, then, that up to the time of Professor Wheatstone there was undoubtedly a distinct apprehension of the dissimilarity of the impressions of any object obtained by the two eyes, and a consequent possibility that drawings might have been produced representing more or less perfectly such impressions, if, indeed, it cannot be admitted that such complementary pictures had actually been produced by Porta and Leonardo da Vinci. The reconciliation of this dissimilarity with distinctness of perception, in the use of two eyes, however, greatly perplexed some, whilst others clearly saw in it a cause of the decided advantage of two eyes in perception of relief. The clearness and exhaustiveness with which the subject was discussed shows, however, that they did not touch the fundamental conception of Professor Wheatstone, as stated in the quotation given from the Report of the British Association for 1838. Taking up the subject at this point, the following question seems to have presented itself to his mind: If two dissimilar plane pictures, produced upon the retinæ of the two eyes *in observing any object*, in some way or other give rise to a resultant mental impression of relief, may not the production of such pictures upon the retinæ *by means of proper plane drawings of the object*, presented simultaneously to the respective eyes, produce the same effect, —the same impression of relief? He then executed such drawings; he devised an instrument to aid in presenting the drawings so that each eye should receive the one proper to it, and the result was a most beautiful verification of the hypothesis involved in the above question.

It was not, then, the production of the complementary drawings, nor the invention of the instrument to present them properly to the eye, that constituted Professor Wheatstone's discovery; but, after the thought had occurred to him to attempt to employ such drawings in that way, the resources of optical science were ample and varied enough to furnish a variety of instruments to aid him; and it seems natural that he should have looked about for instrumental aid in so apparently unnatural a visual effort as it has been shown to be in the discussion of the different ocular methods.

It seems, indeed, that Sir David recognizes the force of the above facts, and consequently introduces Mr. Eliot, a teacher of mathematics in Edinburgh, who had resolved, without, however, publishing or stating his resolution, in 1834, to construct an instrument for uniting

binocular pictures, but delayed doing so until 1839, five years afterward, and, unfortunately for his claims, the year after Prof. Wheatstone had presented his paper and instrument to the world.

ON THE AURORAL DISPLAYS DURING THE MONTH OF FEBRUARY, 1872.

(Extracts from the Monthly Journals of the different Stations established by the Signal Service, U. S. Army.)

LAKE CITY.

Feb. 12th.—A slight aurora.

Feb. 18th.—A very bright aurora in the west. This light may have been caused by fire.

Feb. 28th.—Spots of aurora throughout the western sky. Weather cloudy.

Feb. 29th.—A faint aurora throughout the whole heavens; that in the south somewhat brighter than elsewhere.

JACKSONVILLE, FLA.

Feb. 4th.—Aurora polaris visible from 7.25 P.M. until nearly 9 P.M. One nearly perfect arch, streamers quite numerous and of a rose tint, at 8 P.M.

MOBILE, ALA.

Feb. 4th.—On the night of the 4th a brilliant aurora was visible from 7 to 11 P.M. It became visible in the east, and spread along the sky from a point south of east to northwest, and at times rising in the sky to an altitude of about 60°. At 10.45 P.M. it rose higher, presenting at that time a most brilliant appearance. A portion extending from east to a point east of north, maintained an uniform color varying but little from a beautiful rose to a deep blood. The portion lying between north and northwest and east and southeast were throughout less brilliant, and varying very often in color, sometimes presenting a whitish appearance and at other times deepening to a light rose color; at 9.30 P.M. it disappeared for a short time in the north and northwest, but presenting the appearance of an elliptical cloud in the east, its length being about three times its height, and of a beautiful deep blood color. The base was clearly defined, being about 10″ above the horizon. Between its base and horizon a dense haze existed. It disappeared very quickly at 11.05 P.M.

CAPE MAY, N. J.

Feb. 4th.—Clear and pleasant, with brisk and fresh winds. Barometer rising. Red aurora in the evening, in the southeast.

NASHVILLE, TENN.

Feb. 4th.—Weather cloudy. Wind S E. An aurora made its appearance about 6¼ o'clock, extending from east to west; it assumed no definite shape, but was of an extreme bright red color, and was brightest about 8.36 P.M., when it gradually disappeared, ceasing to be seen at 9.30 P.M.

BALTIMORE, MD.

Feb. 3d.—A brilliant aurora polaris was seen this evening, on the southern horizon, between 8 and 9 o'clock.

BOSTON, MASS.

Feb. 4th.—6.30 P.M. Fine display of aurora polaris south of zenith, of a deep red color.

KNOXVILLE, TENN.

Feb. 4th.—8½ P.M. Brilliant aurora; beams shoot almost north to south, and through the zenith. The sky is deep red.

11 P.M. Aurora disappearing very slowly.

MARQUETTE, MICH.

Feb. 5th.—9 P.M. Brilliant auroral display. The arch throughout very well defined, being of a brilliant color, and of not much elevation above the horizon, the streamers moving rapidly along the arch from west to east, and presenting the appearance somewhat of broad waves of light.

10 P.M. The streamers having subsided, the arch is better defined, but not of such a bright color.

11.20 P.M. Aurora more brilliant than ever, streamers shooting up very high. The arch has not been very well defined during the display, rather resembling a great light in the north, with intervals of almost clear sky. Up to 10 P.M. there was no haze or cloud to be seen beneath the arch, but at this writing a few very long, thin, and perfectly straight-edged clouds are seen at the western end of the arch.

Feb. 15th.—11.20 P.M. An aurora is now visible, consisting of an arch, quite well defined, resting upon a bank of thick dark haze at the eastern end of arch; streamers are observed to be shooting both upward and downward, but not to a great elevation upward, while downward they reach almost to the horizon.

11.30 P.M. The arch has merged into a broad sheet of light, and shows signs of disappearing.

Feb. 26th.—8 P.M. Brilliant aurora; elevation of top of arch about 45°, base nearly touching the horizon; colors principally white and pale crimson.

8.30 P.M. Aurora much fainter; but few streamers visible as yet.

11.20 P.M. Aurora no longer visible.

OSWEGO, N. Y.

Feb. 9th.—Northern lights commenced at 11.30 P.M., lasted until 1.30 A.M.; not brilliant.

Feb. 19th.—Northern lights same as described in article 351, page 176, Loomis. Commenced 7 P.M. and lasted until 12 P.M.; nothing unusual in their appearance.

ROCHESTER, N. Y.

Feb. 28th.—The Assistant Observer, Private Tighe, reports, at 9 P.M. last evening, the existence of two luminous arches, extending across the northern sky, being about two degrees apart, and the upper one, the more luminous of the two, about 60° above northern horizon. He is unable to give duration of this phenomenon.

LYNCHBURG, VA.

Feb. 4th.—The aurora borealis was visible during the night of the 4th. At 7 P.M., owing to the cloudy state of the atmosphere, a reddish hue of the clouds was the only indication of the presence of the aurora. As the night advanced the weather became clear, and that quarter of the heavens from northwest to southwest, from zenith to the horizon, presented a bright red appearance. The aurora grew dim in the southwest and brighter in the west and northwest at 10.30 P.M. At midnight the lights became very bright due north, resembling daylight, while in the rest of the heavens the aurora entirely disappeared.

NEW YORK CITY.

Feb. 4th.—Clear weather and brisk northwest winds. At 6.30 P.M. a brilliant aurora appeared in the north, which soon overspread the whole northern heavens. At seven o'clock it had extended eastward and upward until it occupied a space in the southeast from about 15 degrees to 50 degrees above the horizon, about 70 in breadth, and assumed a blood-red tinge, so dense at times as to obscure the stars. On either side of the crimson was a perpendicular line about 10 degrees in width and 50 in length, of a bright orange and green tint. The display lasted until about 11 P.M., when it gradually disappeared.

PHILADELPHIA.

Feb. 4th.—On the north the aurora borealis was displaying, while on the south the aurora australis reflected back with tenfold beauty the light of its cold antipodes. As, at 7.20 P.M., I opened the latticed door of the shelter, a most brilliant display of glorious crimson light struck upon my gaze. Further observation discovered that a

blood tinted light, ever varying, was extending from the south to the southeast. At times the light would subside to a mellow crimson, and again, with gentle flushings, would shoot up towards the zenith. At first I thought the lurid light was the reflection of some conflagration upon the sky; yet, upon opening the east door, I discovered that the northern horizon was also lighted by a pale silvery light, which at times would assume a tinge of pale green. These phenomena remained visible for the greater part of the night, for at 11.43 P.M., when my last observation was made, the rays of the aurora borealis were plainly and magnificently visible above the bank of stratus clouds that interposed above the horizon. The aurora australis had faded; "t'was 'neath a cloud as dark as woe," for huge and black banks of stratus had piled themselves on the horizon, so lately illuminated by the soft crimson light of the australis. The sky was becoming rapidly overcast, and at 1 A.M. was entirely obscured.

St. Paul, Minn.

Feb. 4th.—A display of aurora was visible in the north and northwest. It was first seen at 6 P.M.; did not present any particular form, but was a diffused light. It had the appearance of crimson sand falling to the earth, then rolling in billows and waving toward the south, and disappearing. It became more brilliant at 8 P.M., and was then of a deep rich crimson color.

Washington, D. C.

Feb. 4th.—The auroral display first attracted the attention of the Observer at 7.15 P.M. Presenting a brilliant carmine color, it gradually crept up from the northeastern limit of the horizon till it reached the zenith, when the rays began to appear divided, and presented an appearance as of a flickering flame darting down toward the southwest.

Apart from this track across the heavens there appeared curious globe-like spots of about 15° in diameter, having the same carmine color, and being arranged by the side of the path of the aurora; not less than three of these spots were noticed.

The auroral track was about 40° in width, less brilliant at the borders than in the centre, and when complete could not be seen below an angle of 30°. The observation was continued until 9.15 P.M., the phenomenon presenting but slight changes.

Another, but not confined to any particular part of the heavens, was observed for a few moments at 2 A.M.

Feb. 5th.—The color was the same as the first, but was somewhat less brilliant.

Chicago, Ill.

Feb. 4th.—At 9 P.M. it cleared, and a slight aurora was perceptible. These have always or nearly always been found at this station to be precursors of colder weather and northerly winds.

Feb. 19th.—A slight dawn-like aurora was observed in the evening.

Feb. 27th.—In the evening there was a slight aurora, resembling the dawn.

Key West, Fla.

Feb. 4th.—At 7 P.M. a faint light, without any definite form or shape, was observed in the northeast, reaching from the east to the north and extending halfway to the zenith; gradually moved westward, passing by the north, until about 2.30 A.M., when its centre had reached the western point of the horizon, and could no longer be observed, in consequence of the sky becoming overcast with clouds. A dense haze was observed at its base during the entire time, and at 9 P.M. large black clouds moved from the west and passed by its base. When it first appeared its color was very faint, and after intervals of five minutes it increased in brightness, its color becoming a rose hue, and again, after an interval of five minutes, it would entirely disappear, and again re-appear, very faint at first, but would gradually increase in brightness, and so on during the entire time it could be observed. It was brightest at about 1 A.M., when it was of a red color, the amount of moisture in the air at the time being 88 per ct.

Charleston, S. C.

Feb. 4th.—An aurora visible in the northeast at 7 P.M., extending from zenith to the horizon, of a light red color at first, but died away into a pale yellow at 9 P.M., when the haze became very dense.

Galveston, Texas.

Feb. 4th.—Cloudy, barometer falling. Brilliant aurora, color bright red; began 6.45 P.M.; too cloudy to see it plainly till about 10.50 P.M., when the sky cleared. It gave a steady light, shining up about 35° above the horizon. Began to disappear 11.30 P.M.; totally disappeared 11·40. Barometer falling, temp. 57° and rel. hum. 100. Wind S. E., 16 miles per hour. Heavy dew falling.

Duluth, Minn.

Feb. 4th.—At 6.30 P.M. very red light running east and west, but more south of Duluth it was brightest at the east. At 9 P.M. beams began to shoot up at the north; it was not very brilliant.

Milwaukee, Wis.

Feb. 4th.—Snow; aurora in the southeast.

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OF THE STATE OF PENNSYLVANIA.

FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. LXIII.] JUNE, 1872. No. 6

EDITORIAL.

ITEMS AND NOVELTIES.

The Boilers Tested at the Exhibition of the American *Institute*, 1871.—In connection with the elaborate and very valuable report of the Committee appointed by the American Institute at its last exhibition, which appears in this number of the "Journal," a short description of the competing boilers tested by it, with engravings, is herewith given from advance sheets of the report referred to.

The Root Boiler (plate vi, figs. 1, 2,) consists essentially of 80 wrought iron tubes, each 4 inches in diameter, and 9 feet long. These tubes are set in brick work, at an angle of about 30° from the horizontal, and are connected together by the system of triangular plates and crowfeet shown in figs. 1 and 2, the joints being formed by the aid of rubber grummets.

The boiler has a steam drum, 18 inches in diameter, and 6¾ feet long. The superheating is effected in the upper portion of the boiler, where the tubes are, like those forming the water space, surrounded by the heated gases. The water was maintained during the trial just above the fourth row of tubes.

The inventor claims that by the contraction of the passages, caused by the method of connecting the tubes, the steam is disengaged from the water in a comparatively dry state.

The Allen Boiler (figs. 3, 4).—This boiler possesses several novel features. There are 9 cast iron cylinders, A, A, A, etc., each 7 inches internal diameter, and 11 feet long; and into each of these cylinders 18 wrought iron tubes, B, B, each $3\frac{1}{2}$ inches in dimeter, and closed at one end with plugs, are screwed. In each section of wrought iron tubes, 9 of the tubes have a length of 3 feet and 2 inches, and the remaining 9 have a length of 4 feet and 5 inches each. The sections are all connected by the cast iron cylinders to a steam drum, C, 2 feet in diameter and 8 feet long; and this drum is connected with another, D, $2\frac{1}{2}$ feet in diameter and 8 feet long. (This drum has been omitted in the engraving.) From this latter drum the steam leaves the boiler by the pipe E. These drums are so arranged as to superheat the steam, being surrounded by the products of combustion: and in the bottom of each of the drums are pipes, F, G, connecting with H, the lowest point of the boiler, to allow the water carried over by the steam to drain back. The feed and the water gauge and gauge cocks are connected to the steam and water spaces by the pipes J, K, L, leading to the steam drum, C, and the cross connection, H, respectively. The wrought iron pipes are conneted to the cast iron cylinders at an angle of 20° from the vertical, the inventor claiming that as the most effective position. The inventor also claims great facility for making repairs by merely unscrewing a defective tube and substituting a good one.

The Phleger Boiler (fig. 5), as built by Messrs. Lady & Verner, of Phleger Safety Boiler and Machine Works, Thirtieth and Chestnut streets, Philadelphia, is described as follows:

The steam-generating surface consists of a series of wrought iron lap welded boiler tubes, 2 inches in diameter, firmly expanded into wrought iron sheets $\frac{7}{8}$ of an inch in thickness. The back flue sheet, with cap bolted on, is free to expand and contract. The tubes are arranged so as to give a free upward flow or circulation of the entire body of water through the tubes to the steam drum, from which it returns by means of a stand or side pipe outside and away from fire surface, which is claimed to give a perfect circuit to the water (as seen by direction of arrows in cut), and to keep all parts of uniform temperature free from scale and sediment, the current washing any impurities in water into mud drum, where it can be blown off at convenience. There are no joints or connections exposed to the fire.

The inventor amongst other things claims for this boiler perfect cir-

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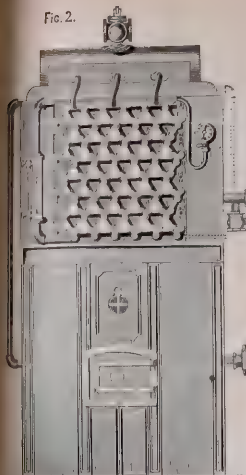
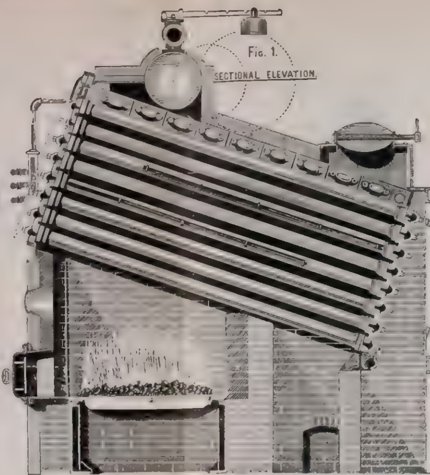
ROOT BOILER.

Fig. 2.



FRONT VIEW



ALLEN BOILER.

75 HP

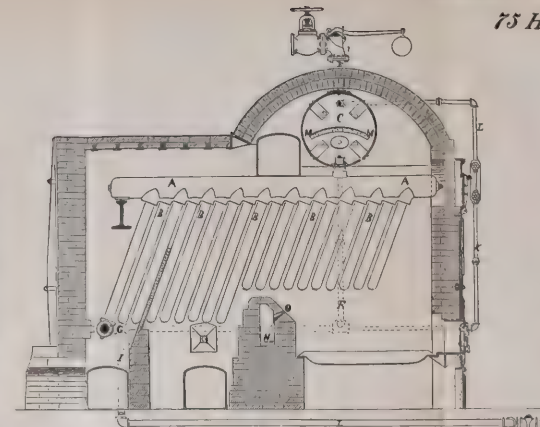


Fig. 4.

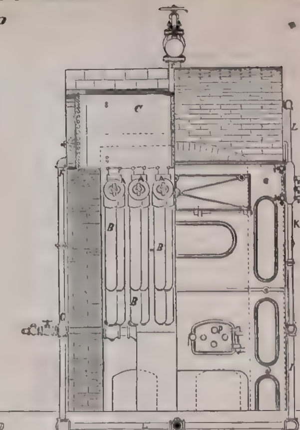


Fig. 5.

PHLEGER BOILER.

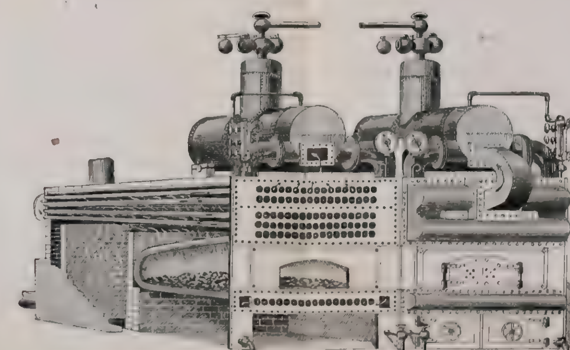


Fig. 3.

LOWE BOILER.

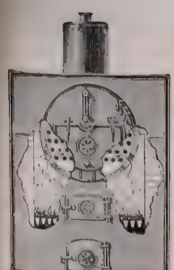


Fig. 7.

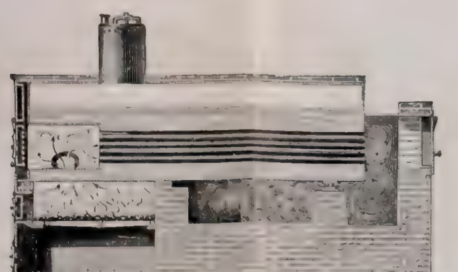


Fig. 6.

culation of the entire body of water, durability, economy of fuel, and great convenience in repairing.

The Lowe Boiler (figs. 6, 7).—This is a tubular boiler, set in brick work. The principal claim of the patentee is an improved arrangement of the flues and setting, for the purpose of securing more perfect combustion. The products of combustion pass from the furnace through openings into the combustion chamber. Air is admitted to the chamber by a register, the amount of opening being varied, until it is judged that the best effect is produced. The further course of the gases is plainly marked by the arrows, through the tubes and under the boiler, passing by a drop flue to the chimney.

By this arrangement of the combustion chamber, the inventor claims to effect a more perfect combustion of the gases of the fuel than can be produced in any other boiler of this class.

In the trial, two boilers, placed side by side, were tested. The larger boiler was 4 feet in diameter, 15 feet and 4 inches long, and contained 45 tubes, each three inches in diameter and 12 feet long. The other boiler was of the same length as the first, but only 3½ feet in diameter, and contained 36 tubes, of the same dimensions as those in the first.

The Blanchard Boiler.—Not having received the engraving of this boiler, an intelligent description is difficult. It can, however, be stated that a mechanical draft is employed. The air, instead of being forced through the ash pit, as is usual, is drawn by the action of a fan-like screw placed in the smoke pipe above the heaters, the fan being driven by a belt from the fly-wheel of the feed-pump.

By this arrangement the inventor claims that he can utilize the products of combustion in a very thorough manner, and also that he can employ a much larger ratio of heating to grate surface than is commonly possible. In the smoke pipe is placed an arrangement of tubes for superheating the steam, and above this a second series for heating feed-water.

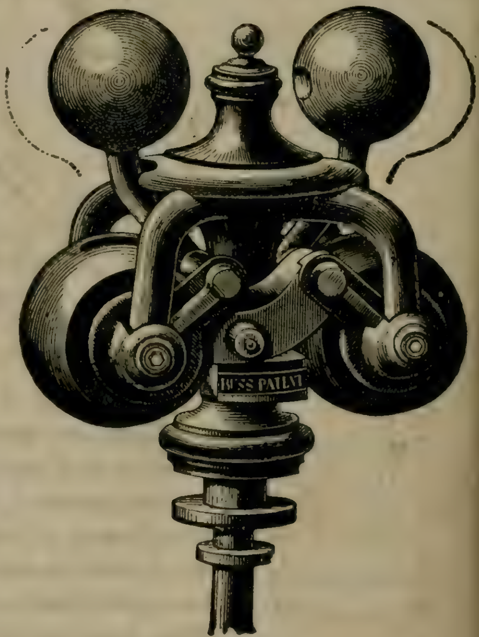
New Lecture Experiments.—*The Action of Lenses Illustrated.*—In the "Quarterly Journal of Science" for April is an account of a very ingenious arrangement of the vertical lantern by Dr. R. M. Ferguson. In this an ordinary retort stand is used for the framework, and the mirrors, &c., are attached by the usual rings and clamps of that apparatus. The most important feature, however, is the substitution of a glass bowl or evaporating dish, full of water, for the horizontal element of the condenser.

Carrying out this suggestion, I find that the apparatus may be made yet simpler and less expensive by replacing the objective with a watch glass, full of water, which, owing to the favorable conditions fully discussed in this journal (vol. 54, p. 339), gives a very good image. Carrying out this idea a step further, we have an excellent illustration of the action of refraction in producing images with lenses, and some of its conditions.

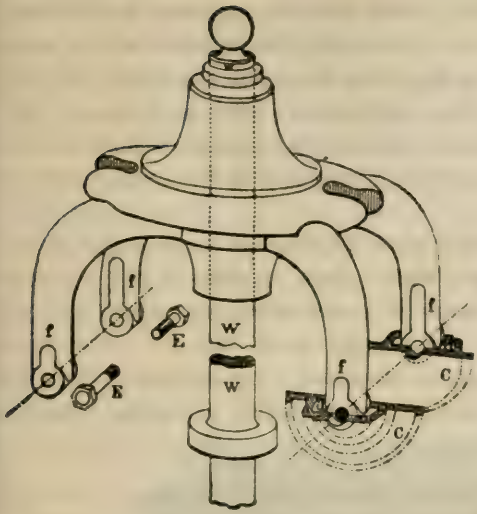
Thus we place a well-defined glass photograph as an object in the vertical lantern, and an empty watch glass in place of the objective. As a matter of course no image is produced on the screen, but only a nebulous patch of light. On pouring water into the watch glass, however, a well-defined image is produced. On replacing the water by alcohol, muriate of tin, or other more highly refracting liquid, a ens of higher power is obtained. HENRY MORTON.

Statistics of Coal.—From the trade journals it appears that the amount of coal now shipped from Pittsburgh is enormous. During one week there were shipped from that port, mainly to Cincinnati, seven millions five hundred and three thousand bushels of coal.

The Buss Governor.—This apparatus, of which the annexed cuts are representations, is a centrifugal governor, of German invention, manufactured by Schaeffer & Budenberg, in Hamburg, and has been extensively introduced in machine shops abroad. There is claimed for it remarkable sensitiveness, great energy, and great reduction of frictional resistance. (For the illustrations we are indebted to the kindness of the Editor of our esteemed contemporary, *Der Praktische Machinen Constructeur*.

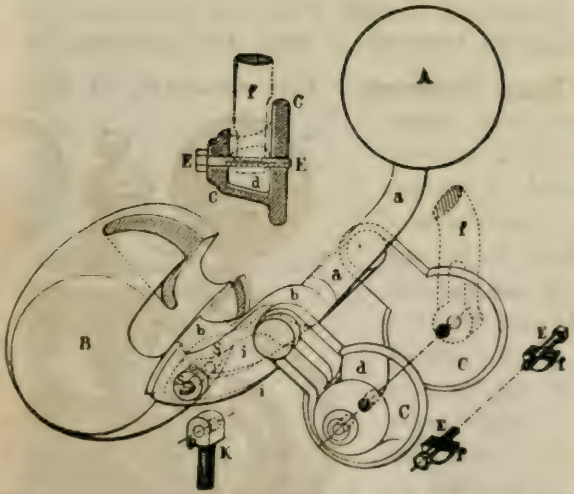


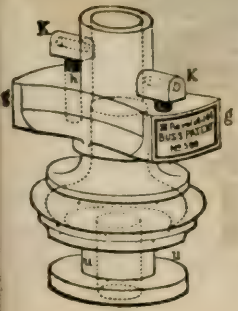
The governor consists essentially of the following



parts: A vertical shaft, a cast-iron pendulum bearer, two cast iron pendulums with four steel pins, and a cast iron box.

The attachment of the vertical axis can be arranged to drive the apparatus either from above or beneath. The cast-iron pendulum bearer is attached to the shaft W, its four crossing arms f, f_2, &c., carry the axles E and E, of the pendulums. Each of the pendulums consists





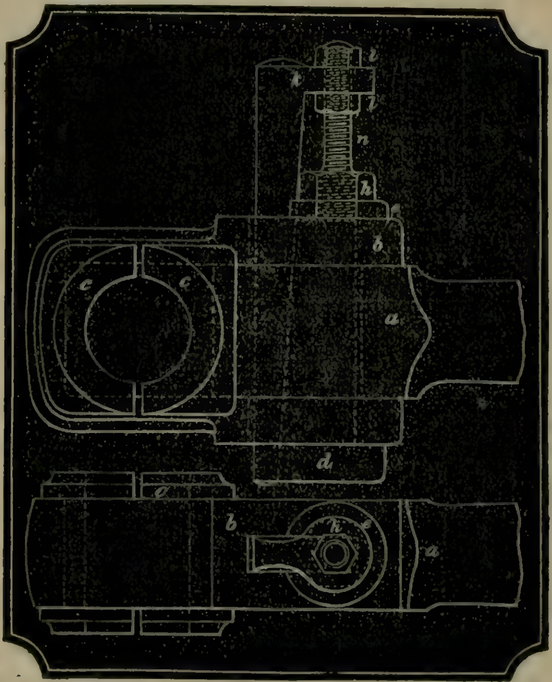
mainly of a ball A, and a barrel-shaped weight B. These are attached by arms a, a and b, b to two cases C and C. To each of these last is attached an arm f, of the pendulum bearer, and through each of the cases C and arm f, fitting into it, there is screwed a steel pin E. Two of these pins (which are at some distance from each other), form the axis of the pendulum.

The illustrations afford exterior and sectional

views of the apparatus, which, though complex in form, is similar in the principles of its operation to other centrifugal governors.

Stub-end of Connecting Rod.—In this stub the block, *a*, strap, *b*, and boxes, *c c*, are made in the usual way. The key, *k*, has a lug, through which the belt, *n*, an extension of the gib, passes, a slot hole being provided to allow for draft of key, and nuts, *i i*, to hold key securely in place. The head, *d*, of gib holds the strap in the usual way, but on the other end a nut, *h*, is placed, resting on a circular washer, *e*, notched at the key. The diameter of this part of the gib is made more than the thickness of the gib, to gain strength, but the extension, *n*, may be made less.

This plan may be resorted to with advantage to strengthen existing stubs, giving the bolt to the strap and screw adjustment and holding



to the key. J. H. C.

Crystallized or Burnt Iron.—In a previous number of the "Journal," the views of Mr. W. M. Williams upon the origin of burnt iron, or iron which has been damaged by reheating, with the arguments sustaining them, were presented to our readers, in which that

gentleman supported the opinion that the injurious effects are produced by the absorption of oxygen, which really burns the substance, partially removing, in the case of steel, the carbon and imprisoning carbonic oxide in its interior, and in case of iron, oxidizing the metal itself; in either case, breaking the continuity of the texture, and hence its tenacity, by the introduction of worthless combustion products.

M. Caron. maintains, however, that the deterioration of "burnt" iron is due, not to the absorption of gases, but simply to the action of heat modifying the molecular constitution; and this opinion he supports by the following experiments: A piece of iron, with good fibrous properties, was broken into small pieces; some were placed in the fire of an ordinary forge, and raised to a welding heat; others were placed in a porcelain tube, and raised to the same temperature in a current of hydrogen or nitrogen. Both were similarly cooled, and both presented the crystalline structure of burnt iron.

The same author supports the opinion that vibration has not the slightest effect in rendering iron brittle, or in modifying its fibrous texture, and that the explanation of frequent breakages is to be ascribed rather to bad form, or to the original inferiority in the quality of the iron. He likewise combats the idea that the frequent fracture of railway axles in cold weather, and the crystallized texture of the broken bars, is any proof that cold is the cause of the crystallization and consequent brittleness, urging that there is no evidence this was not the condition of the metal before use, and that the greater hardness of the ground, greater severity of shocks, &c., are the more rational reasons for such accidents.

New Mode of Propelling Ships.—A contemporary contains an account of an experimental trial upon a small model of a vessel, the design being to test the practicability of a new mode of propelling ships. The inventor proposes, by a novel contrivance, to make the waves acting on the hull of the ship do the work of propelling it. Beneath the keel of the vessel he fixes two oblong steel frames, each fitted with two sets of blades, which open and shut crosswise. One frame is secured to the fore part, the other to the stem of the vessel. When the vessel rises in the sea, the presence of water upon the frames, it is said, forces her forward; and when she sinks, the opening of the blades would form the opposite angle, and continue the onward motion. The opening or closing of the blades on either side,

as the vessel rolls, it is claimed will have the effect of steadying the motion of the ship. The angle of the frames may be increased or diminished according to the state of the weather. To stop, the blades in the frames are closed.

The inventor believes that the plan would furnish sufficient propelling power to ships not requiring to travel with great speed, and would supply them with a limited amount of rigging as auxiliary against accident, or whenever there is not sufficient motion at sea to raise the vessel several feet, which is rarely the case. At the trial, a miniature vessel, 7 feet in length, held its way against the tide, and even in comparatively still water travelled at considerable speed.

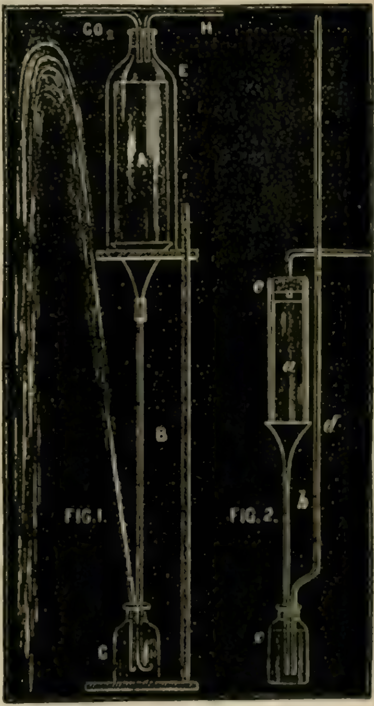
Wrought Iron Ties.—Certain English journals speak highly of the anticipations formed of the new railway sleeper recently brought out in England. The constructors of railroads in tropical countries, it seems, are disposed to regard them with special favor. In India, our authority tells us, unusual difficulties are experienced with the wooden sleeper—the dry rot and the white ants seldom allow them, even when protected by chemical preparation, a longer lease for usefulness than three years. The new sleeper is expected to show decided advantages. It is made up of a number of webs and plates of rolled iron, riveted together and pierced with bolt holes for the chains. On the score of cost, it is estimated that this will not exceed that of the best wooden sleepers by more than a shilling each, while ten times the wear is anticipated from them in tropical countries, and three or four times in Europe. Those in use on several Belgian railways are pronounced to be all that are claimed for them.

A Submerged Bridge.—A bill is at present pending in Congress to incorporate the New York and Brooklyn Submerged Tubular Bridge Company, the object of which is to run a tube under the East River, to connect the two cities named above. The bill will authorize the laying of a wrought iron tube 2640 feet long, 60 feet broad in the clear, and 24 feet high, at a cost of $2,500,000. The tube is designed to accommodate foot passengers, vehicles and railway cars. It is anticipated that the committee having it under consideration will report favorably upon it.

Lecture Illustrations of Diffusion, &c.—Mr. Ferd. Fischer illustrates the phenomenon of diffusion of gases in the following manner:* This apparatus, figured opposite, is a modification of the one

* Ber. d. d. chem. Gesell. v, 264.

nearly always used for the purpose, and consists essentially in surrounding the porous cylinder, A, (fig. 1), with a bell glass, E, having a doubly perforated cork, furnished with glass tubes for supplying the interior with various gases; while the long tube, B, terminates in a flask, C, nearly filled with a colored liquid, and furnished also with a doubly perforated cork, the second opening in which is occupied by a small tube terminating just above the flask.



If now carbonic acid gas is introduced into E, the colored liquid in C rises in B to a considerable height; a strong current of hydrogen through the other tube causes the fluid almost instantly to be ejected from C to a height nearly equal to that of the apparatus.

Specific Gravity.—Fig. 2 is a modification of the first, for the purpose of simply illustrating the relative specific gravity of gases; *e* is an ordinary lamp chimney set upon the edge of the funnel, while *d* is prolonged from the lower flask to a considerable distance.

By leading into *e*, a gas heavier than the atmospheric air, the liquid in *c* rises in *b*; the heavier the gas the higher the rise in *b*.

Gases lighter than the air drive the liquid up the tube *d*; the lighter the gas the higher the column rises.

Flame Reactions with Hydrogen Gas.—Mr. W. F. Barrett has published some interesting observations on the phenomena associated with a hydrogen flame, of which a brief abstract is given below.*

The gas is thoroughly purified by washing with potash and subsequently with nitrate of silver or perchloride of mercury, and is to be led through a black rubber tube to a steatite jet, and burned in a perfectly dark room free from dust. Under these circumstances, it appears that the flame possesses a faint reddish-brown tinge, while a stream of lumin-

* Nature v. 482.

osity extends upwards beyond the flame proper, to more than six times its length. When brought into contact with solid bodies, in many cases phosphorescent effects are produced. Sandpaper brought into it for a moment shows a vivid green light, remaining for some seconds after the flame is extinguished. Writing paper, marble, gypsum and granite gave similar effects. The presence of the least trace of sulphur, either in the air in the delivery tubes, or upon the objects tested, invariably cause a deep blue coloration of the flame. As a chemical reagent for detecting sulphur, the author pronounces the flame to be wonderfully sensitive. Phosphorus and its compounds give a green color to the flame, and carbonic acid at once imparts to it a pale lilac tinge.

From these observations it would seem that pure hydrogen might be made serviceable in producing phosphorescent effects, and in testing for slight traces of sulphur, phosphorus and certain gases.

A New Test for Arsenic.—Bettendorf* has simplified Hager's method of testing for this substance, and, it would seem, has rendered it peculiarly suitable for testing pharmaceutical preparations for slight impurities from this element.

The method of testing commercial sulphuric acid for traces of arsenic will give a fair illustration of the author's process.

A small quantity of protochloride of tin, in a shallow dish, is covered with pure hydrochloric acid (1·12 sp. gr.) until it is dissolved. To this is added, drop by drop, the sulphuric acid to be tested, the vessel being agitated at each addition. This addition will cause considerable heating, and if no arsenic is present the liquid will remain clear. If arsenic is present in the smallest quantities the liquid will be colored first yellow, then brown, and finally a dark greyish-brown, becoming at the same time turbid.

The process, while far more readily carried out than Marsh's, is declared to be nearly equal to it in delicacy.

A New Photographic Process.—A printing process, by which a photographic image can be developed upon paper, sensitised with various metallic salts without the agency of light, has lately been announced to the French Academy by Prof. Merget of Lyons. The observations upon which this process, which bears a very remote resemblance to the old daguerreotype, is founded, are stated to be that

* Dingler's Jour., ccii, 385.

mercury possesses the property of volatilizing continuously at all temperatures, that these vapors may be condensed upon numerous substances (such as carbon, platinum, &c.,) without chemically affecting them,—while upon the solutions of salts of the precious metals these vapors have a rapid reducing action. This reducing action being purely chemical, can, therefore, take place in the dark, and the printing process is therefore rendered independent of the light.

The following is given as the *modus operandi:*

An ordinary glass negative, protected from the chemical action of the mercury by a coating of platinum or carbon particles (how?) is exposed to the action of the vapors. The vapor condenses more or less densely upon the image, and the plate is then brought into contact with the sensitised paper; prepared, as stated above, by dipping into a bath of any of the soluble salts of the precious metals. The mercural particles covering the image at once reduce the salt upon the paper, the consequence being the production of a metallic image with every gradation of tint upon the paper. When the nitrate of silver is used, the print is said to be identical with that obtained with the ordinary printing process, and is treated in a similar manner to render it permanent and heighten its tone. In this way, it is said, prints may be secured in platinum or palladium, which need simply to be washed with water to be far more durable than the paper upon which they are attached.

This plan, if the details are as simple as described, may prove to be of much practical interest, perhaps even in the reproduction of photographic images by mechanical means, which is now attracting so much attention.

The Oxygen Light.—The plan of Tessié du Motay, which has been for some time past in operation upon some of the principal boulevards of Paris, has been found unsatisfactory in several particulars, and we are informed that the lights have been removed. In addition to the use of burning gas with oxygen, it may be stated, this process requires the introduction of a super-carburetting apparatus. It would seem that practical difficulties other than the cheap preparation of oxygen gas, must be overcome before an oxygen light can be made successful.

The Temperature at the Sun's Surface.—A number of eminent scientists are at present engaged in the solution of this interesting problem. The results thus far announced are extremely unsatis-

factory; some of them differing very widely. As an instance of this difference in opinion, it may be said that the famous astronomer and spectroscopist, Pater Secchi, maintains this temperature to be about ten million degrees Centigrade.

At a recent séance of the French Academy, in defending his estimate against the much lower figures of Ericsson, Zöllner and Faye, St. Claire Deville asserted that he was engaged in investigating the subject, and that his results fixed the temperature at about three or four times the melting temperature of platinum, about 6000 to 8000 degrees (C.) Mr. Vaulle also announced an ingenious theory upon the same subject, fixing the debated figure at 10,000 degrees (C.) Finally M. Fizeau stated that, having compared the solar light with that of the carbon points of the electric light, he had been able to estimate that the former was about three times as intense as the latter, and hence, assuming the relative calorific intensity to be in proportion to the luminous intensity, he had arrived at the figure of 8000 degrees (C.) as the correct one.

A New Use for the Aniline Colors.—Mr. F. Springmühl recommends the use of alcoholic solutions of various gums (shellac, sandarach, &c.), to which various aniline colors have been added, in coloring all kinds of paper, leather, linen, &c.*

The gum solution, which should be thin, penetrates entirely through the paper and gives to it an even tone. The operation is simply to place the coloring liquid in a shallow dish, and to draw the substance to be colored through it, which is subsequently hung up to dry; when dry another color can readily be produced upon one of the sides. Sandarach is said to produce matt; shellac and most other gums, a lustrous color. By adding to the lac solutions a small quantity of some etherial oil, the substance may at the same time be perfumed. By judiciously mixing several of the lacs, any desirable tint can be produced.

A Pressure Guage for Guns.—The principle suggested by Tresca's experiments on the flow of solids has, we are informed, been applied in practice for determining the pressure produced in the bore of large guns.† A cylindrical hole, bored into the gun, is filled by a block of lead, supported behind by a steel block, through which is a

* Zeitschr. f. Fārberei, 1871, No. 41.

† Eng. and Min. Journ., xiii, 283.

small cylindrical hole. When pressure acts on the lead, a portion of it is forced into the hole in the steel block. By estimating the volume of the lead found in the cavity after a discharge, a means of measuring the pressure exerted within the gun is given.

Separation of Potassa and Soda.—One of the nicest operations in the analytical laboratory, demanding at once patience and skill, consists in the separation of these substances. The reagent usually employed in this separation is the chloride of platinum, and its employment is, in many respects, unsatisfactory.

In this connection M. Th. Schlösing has presented to the French Academy a paper, in which he makes a most favorable presentation of the method long ago proposed by M. Chevreul (but which, if it has ever been used, has been altogether abandoned), founded upon the insolubility of the perchlorate of potassa in alcohol. It appears that the potash salt is the only one with this acid which gives such an insoluble precipitate, and a ready method of separation is thus given; so easy, indeed, from all appearances, that the difficulty of preparing the reagent has probably been the cause of its abandonment for so long a time. M. Schlösing, after stating the results of some analyses conducted upon this plan, and which are extremely accurate, gives a method of cheaply preparing the perchlorate of ammonia, the reagent which he prefers for the purpose. One method which he recommends, is to form the chlorate of soda by leading chlorine into a solution of common salt. From the dry salts obtained by evaporation to dryness, the chlorate alone deposited by saturating boiling water with them; and cooling, the chloride remains in solution. The perchlorate is formed from the chlorate so obtained by heating; the mixture of salts obtained being separated by dissolving in very little water, when only perchlorate goes into solution. To this is added boiling water and a saturated solution of chloride of ammonium, and upon cooling, the desired salt, perchlorate of ammonia is obtained in large crystals.

Noncombustibe Coatings for inflammible substances, like wearing apparel, &c., have been frequently recommended, under various circumstances, to prevent or at least to greatly mitigate the dreadful accidents which are of such common occurrence.*

With this object, M. A. Pastera, while approving of the use of the tungstate of soda, recommends the substitution for it of a cheaper

* Chem. News, xxv, 202.

mixture, which he asserts to be equally efficient, viz., a mixture of 4 parts of borax and 3 parts of sulphate of magnesia. These substances are to be mixed together just before being needed, dissolved in from 20—30 parts boiling water. The goods are then to be immersed, wrung out and dried.

Obituary.*—SAMUEL F. B. MORSE.—"Prof. Morse died at his residence, in New York City, on the 4th of April, at the advanced age of 81 years. Few Americans have attained so world-wide a renown as Mr. Morse, growing chiefly out of his success in devising and introducing the system of electric telegraphy which bears his name.

"The earlier years of his life, after graduating at Yale College, in 1810, were devoted to the study of the fine arts, which he pursued for some time in London, under Benjamin West, the painter. In sculpture he was so successful that his 'Dying Hercules' was crowned by the gold medal of the Adelphi Society of Arts, of London.

"The germs of his immortal invention, which were undoubtedly long slumbering in his mind, appear to have been stimulated by a discussion which took place on board the packet ship 'Sully,' in the autumn of 1832, while on his way to America.

"Soon after his arrival in New York he occupied himself in maturing his plans by an attempt to construct an apparatus. In 1835 he completed his first rude single receiving instrument, which he produced in duplicate in 1837. In the January number of 'Silliman's Journal' for 1838 will be found the first notice of the Morse system of telegraphic notation, with a specimen of the record then used.

"After several years vainly spent in endeavoring to secure assistance from his own government, and recognition of his rights abroad, he was gratified in receiving, on March 4th, 1843, an appropriation of $30,000 from Congress, to aid in building a telegraphic line between Washington and Baltimore, which, after many difficulties, he accomplished in 1844.

"From this first successful attempt, the system of Morse has spread with great rapidity, and is now in use in almost every civilized country. Honors were showered upon the inventor by most of the leading governments of Europe, in honor of his eminent services.

"Prof. Morse was distinguished by great amenity of manners, and

* From a notice by Prof. B. Silliman, in the Amer. Jour. of Sci., iii, III, 399.

kindness of heart, which endeared him to a large circle of friends. He was emphatically an *inventor*, using the discoveries of science to perfect his inventions. Gifted with a far-reaching mind, and indomitable energy, his faculties were employed in conferring a great blessing upon the hmuan race."

Steam Boiler Explosions.—We have been favored with a copy of a letter of Judge J. P. Bradley, of the Supreme Court of the U. S., to the Secretary of the Treasury, strongly recommending better legislation in this matter, and urging a thorough system of experiments upon boilers actually in service, to be authorized by Congress, and to be supported by a liberal appropriation of money—the object being to determine the faults in ordinary construction of boilers, to devise means of preventing dangerous pressure, and to acquire certainty concerning as to the true causes of explosions, so that the penal laws on the subject may be enforced.

The following is a draft of the act, which it is hoped will receive the favorable attention of the Secretary and of Congress:

AN ACT TO AUTHORIZE INQUIRIES INTO THE CAUSES OF STEAM-BOILER EXPLOSIONS.

Be it enacted, &c.

SECTION I. That the President of the United States be, and he is hereby, authorized to cause such experiments to be made and such information to be collected as, in his opinion, may be useful and important to guard against the bursting of steam-boilers; and that he be required to communicate the same to Congress; and that the sum of one hundred thousand dollars be appropriated for the purpose of this act.

OPTICAL SECTION.

(Extracts from proceedings of the stated meeting, held April 27th, 1872.)

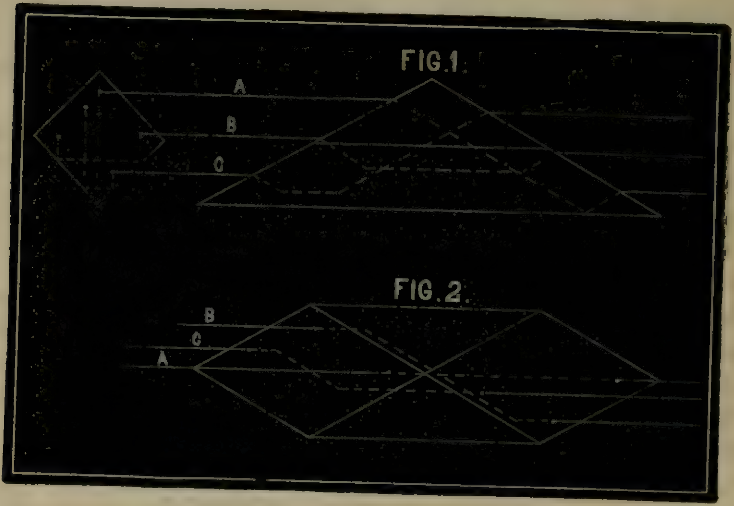
A New Erecting Prism.—BY JOSEPH ZENTMAYER.—Mr. Joseph Zentmayer exhibited and described a single prism, which erects the image completely, and in such a way that the incident and emerging rays are parallel, which, as far as we know, was never accomplished before.

In connection with the microscope, as it was shown, it interfered very little with the definition, and, although the light is twice refracted and reflected, the loss of light is much less than one would expect.

With the microscope, the prism is placed right above the objective, and the instrument may be used in any inclined position.

A pair of such prisms might be used also for an erecting binocular microscope, of which the two bodies have the same inclination to the stage.

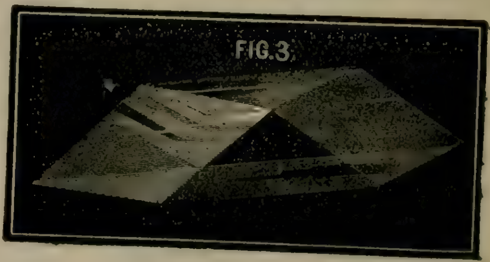
Fig. 1 shows the front and profile of the prism. The projection of the front is a square, that of the profile an isosceles triangle. The



angles at the base of the triangle are 27°19 for crown glass of a refracting index of 1·53, in order to obtain the greatest aperture combined with the smallest prism.

Fig. 2 is a view from above. The rays A, B and C of figs. 1 and 2 are the identical ones, their dotted parts are the projections of the rays inside of the glass, and their course may be readily followed in the profile, fig. 1, where the upper ray, A, emerges as the lower one, and the lower ray, C, as the upper one.

As the ray A enters in the perpendicular line above the lower edge, it will not be reflected out of its plane, while the rays B and C, entering the left side of the prism, reach the inclined faces, from which they are reflected to the opposite lower one, and are changed in their course



to the right, from here again reflected, to emerge at the corresponding opposite point.

Fig. 3 is a perspective representation of the prism.

Civil and Mechanical Engineering.

REPORT OF THE COMMITTEE OF JUDGES UPON THE TRIAL OF STEAM BOILERS.—AM. INSTITUTE, 1871.

The report of the Committee of Judges of Department V, Group I, upon the steam boilers placed in competition at the Fair of the American Institute of 1871 has been made public.

The boilers tested were five in number, the Root, the Allen, the Phleger, the Lowe and the Blanchard.

We make room for extended extracts from the report, as we believe this to have been the first critically exact test of the steaming power and the economical performance ever made upon a large scale, and it is therefore of exceptional value to all steam users and boiler manufacturers, as the only available source of accurate information in regard to the types of boiler tested and, as what the Committee designed to make it, a reliable *standard* of comparison.

The Committee, after considering the relative standing of the boilers as regards safety and durability, and expressing a belief in the ultimate success of that class of boilers called "sectional," proceed as follows to describe their method of determining the value of the boilers under consideration in *economy of fuel and capacity for making steam*:—Ed.

On these two points your Committee felt it their duty to make a careful report, based upon a thoughtfully devised and critically accurate series of experiments.

The usual test of the economy of a boiler and of its capacity for making steam consists simply in determining the quantity of water passing through it and the amount of fuel consumed in the same time, taking the weight of water used per pound of coal as a measure of the economy, and the total amount of water recorded in a given time as a measure of the steaming capacity.

But steam boilers usually—and invariably when unprovided with superheating apparatus—furnish "wet steam," and the weight of water passing off unevaporated is sometimes greater than the real weight of steam made. In order to make a reliable and valuable report upon these points, it becomes necessary to determine what is

the *real* evaporation of each boiler and what weight of water passes over unevaporated.

Another extremely important fact, and one which should alone induce the Committee to propose and the Institute to permit them to adopt an exact method of determining the true evaporative efficiency of the steam boilers presented for their judgment, is that ignorant or dishonest venders of peculiar forms of boilers have frequently deceived the public and have imposed upon purchasers by apparently well-substantiated statements that their boilers have, by actual test, evaporated fourteen, fifteen, or even in some cases twenty pounds of water per pound of fuel consumed—the purchaser being unaware of the fact, so well known to scientific men and to engineers, that were it possible to obtain one pound of coal absolutely free from all impurities and composed of pure carbon, it would, if burned where no loss of heat could take place, and with the feed water at a temperature of 212 degrees Fahrenheit, evaporate but about fifteen pounds of water, and that under the usual circumstances of comparatively cold feed water and high pressure of steam, and with waste of heat by the chimney and in every direction by radiation, *very much less than fifteen pounds* must be evaporated by the very best boiler that man can build.

In order, therefore, to assist honest and skillful builders in preventing such injury of their business by those who would either knowingly or ignorantly take advantage of the lack of information possessed by the public, the Committee considered it a duty and a privilege to furnish, if possible, a weapon that might be made effective in protecting the public as well as manufacturers against such ingnorance or dishonesty. This they proposed to do by determining accurately the performance of these five boilers, which they considered to include some that rate among the best boilers made, *and thus to furnish a standard* that should at all times be valuable for purposes of comparison.

The method adopted by the Committee of Judges is an extremely simple one in principle, and has often been before proposed by engineers. Its earliest conception, probably, dates many years back. The expense attending the building of the necessary apparatus and the preparations for and the prosecution of such an exact investigation, has prevented the earlier adoption of the plan, notwithstanding the fact that its importance has long been recognized. The intelligent liberality of the Board of Managers, who promptly acquiesced in the

proposal of the Committee, and directed the committee of the board, to whom was assigned Department V, to assist in the prosecution of the work, has enabled the American Institute to practically inaugurate this method of testing steam boilers. The apparatus required in conducting the proposed tests was prepared by direction of the chairman of the committee, under the immediate supervision of Mr. J. W. Blake, the Superintendent of Machinery. To the competing manufacturers, as well as to the Superintendent, the Committee are indebted for valuable suggestions.

A large wooden tank was prepared, in which was built a surface condenser having an area of about eleven hundred (1,100) square feet of cooling surface. This latter was made by connecting up the requisite number of tubes, obtained from the Root Steam Engine Company, the peculiar method of connection adopted in the Root boiler affording excellent facilities for so doing. The Committee are greatly indebted to Mr. J. B. Root for assistance kindly tendered in this matter. Water from the hydrants was led through Worthington meters into the lower part of the tank, and, rising among the tubes of the condenser, overflowed at the top.

The steam from the boiler on trial entered the tubes at the top of the condenser, and the water of condensation flowed out at the lowest point. The currents of steam and of condensing water thus moved in opposite directions, and the steam was condensed completely with the least possible quantity of condensing water.

Thermometers were carefully made for the occasion by G. Tagliabue, and were placed as follows: One having a scale ranging from 30 degrees to 101 degrees Fahrenheit was placed at the inlet of the injection water, and its reading indicated the temperature of both feed and injection; one ranging from 100 degrees to 175 degrees Fahrenheit was placed at the mouth of the overflow pipe, and exhibited the temperature of the condensing water when discharged from the tank; one thermometer with a range of from 45 degrees to 175 degrees Fahrenheit was so placed as to indicate the temperature of the water of condensation when leaving the condenser.

Another thermometer was placed in the steam space of the boiler,

The pressure of the steam was indicated by two recording gauges. furnished by their respective patentees, M. B. Edson, and D. P. Davis, and both gave satisfactory evidence of efficiency. The indications of the former were so accurate that it was made the standard during the trial, and the latter, also remarkably accurate, by its record

of time as well as pressure, was a most valuable check upon the record of the log as obtained by observations at regular intervals.

The quantity of water passing through each boiler was determined by weighing it, 300 pounds at a time, on carefully adjusted scales.

The Superintendent of Machinery and his assistant, Messrs. J. W. Blake and J. B. Fitch, who, representing the Committee, had immediate charge of the trials, were aided, except in the test of the Blanchard boiler, by students Henderson, Hewitt, Poinier, and Post, of the *Stevens Institute of Technology*, who, under the instructions of the Chairman of the Committee, kept the log with commendable exactness, and rendered very valuable assistance.

The coal used during the whole series of trials was from the Buck Mountain Coal Company, Philadelphia, Nathan Hilles, President. It was found to be of excellent quality, and the results of the test are, therefore, more valuable as a *standard representing the efficiency of good apparatus with good fuel.* The analysis of this coal, as determined by Professor Walter R. Johnson, is given as follows:

Water, ...	0·390
Gaseous matter, including some agate, volatile at bright red heat, ...	5·515
Carbon, ...	91·016
Earthy matter and oxyd, . . .	3·079
	100·000

It would be interesting to learn the constituents of the "gaseous matter given at 5·15 *per centum*, but this the Committee were unable to ascertain. If there were, however, any combustible gases, it is exceedingly unlikely that they existed in sufficient amount to appreciably raise the evaporative efficiency of the coal, as the steam generating powers of the anthracites seem to be precisely proportional to the amounts of carbon they respectively contain. This fact was well proven by Professor Johnson, in the course of his very extended and valuable researches upon the constitution and value of American coals. (See Report on American Coals, p. 586.) The total heating value of this coal, therefore, provided all waste could be prevented, is readily calculated, and would be 13,197·32, "*British thermal units;*" *i. e.*, one pound of this coal, burned without waste, should be capable of raising the temperature of 13,197·32 pounds of water one degree Fahrenheit. This would be equivalent to evaporating 13·65 pounds of water at the temperature of 212 degrees Fahrenheit, and under atmospheric pressure. In comparing this result with the actual per-

formance on the test, it should be remembered that a large amount of coal always falls through the grate unburned, and thus greatly reduces the practical efficiency of all coals. The amount of this loss can only be approximately estimated, and the Committee judge it to have averaged at least fifteen *per cent.* during these trials.

The evaporative power of pure carbon, which has usually been found to be capable of developing 14,500 British thermal units, is fifteen pounds of water per pound of carbon, the water being evaporated under the pressure of the atmosphere at a temperature of 212 degrees Fahrenheit. All of the results obtained by the Committee are reduced to similar standard measures of thermal units developed per pound of *combustible*, and to the equivalent evaporation from 212 degrees Fahrenheit. It is by the comparison of these reduced observations, that the relative economic efficiencies of the competing steam boilers are to be determined.

The preparations for the trial having been completed, the following letters of instruction were written, and forwarded to the Superintendent of Machinery, by whom their contents were communicated to the exhibitors, and the agreement of each to the proposed terms was a condition precedent to admission for competition:

FAIR OF THE AMERICAN INSTITUTE,
NEW YORK, *October* 31, 1871.

To the Superintendent of Machinery:

SIR,—The Committee of Judges of Department V, Group I, having determined to make a thorough test of the economic values, and of the steaming capacities of the steam boilers entered for competition, you are hereby authorized and instructed to make the necessary preparations for such a test.

The steam from each boiler, when under test, will be conducted into a surface condenser of a capacity of at least eight hundred (800) square feet of condensing surface; the *water of condensation* will be collected in a tank placed beneath the condenser, and there measured; the *feed* water will be measured by a meter, and the *condensing water* will be measured in the same manner, the meters being previously tested.

The pressure of steam will be maintained constant (at seventy-five [75] pounds), by means of a safety valve placed between the boiler and the condenser, and the Committee desire that the safety valves entered by Messrs. Bulkley and Lynde be used, if possible, for this purpose, and that they thus be tested.

Each exhibitor will see that his boiler is ready for the test, his steam pipe well covered, and valves in good order. He will, before his boiler is connected for test, hand to the Committee, through the Superintendent of Machinery, a statement of the amount of heating and of grate surface in his boiler, and a further statement, that he has read this letter of instructions, taken a copy, and that he is ready to go on with the test as herein proposed.

Any exceptions taken to the proposed test, or any detail thereof, must be forwarded to the Committee, in writing, previous to entering upon the test. Any exceptions taken to the action of one exhibitor by another, or to the decision of the Judges during the trial, will be presented promptly in writing.

It is to be understood that the proposed test is made for the purpose of enabling the Committee of Judges to make up their report to the Managers, as required by regulation, with intelligence and confidence.

In conducting the test, you and your assistant are authorized to superintend and to keep the log, with the aid of such other assistants as the Committee may appoint.

The trials will be of twelve hours each, and the boilers will be tested successively in an order that will be determined by lot.

Fires will be started at nine (9) o'clock in the morning with *dry wood*, of which you will see a good supply on hand; and at the moment when steam issues freely from the safety-valve of the boiler, the test will be considered as commenced, and the fuel will be taken from the coal pile. No more wood will be used.

The coal will be weigh'd in buckets, carefully counterweighted on the scale, and always filled to the same weight precisely. The scales are to be tested and officially sealed before the trial.

The ashes will be weighed *dry* in a similar manner.

The dampers will be fixed wide open, unless it should become evident that the boiler "primes" or "foams" seriously in consequence.

Each half hour there will be noted in the log the time, height of barometer, steam pressure (from the same gauge in all tests), weight of coal used, weight of ashes removed, temperature of external atmosphere, of the feed water, water of condensation, steam in boiler, steam pipe, condensing water before and after leaving condenser tank, gases in flues, four feet, as nearly as is possible, from nearest heating surface, the volume of water of condensation, and the reading of the meters.

The fires will be attended to by the exhibitors, and managed as they may think proper. The water level will be fixed at a proper height, and a thread tied around the gauge-glass at that point, its height above the bottom of the glass being recorded; and the water will be kept, as nearly as possible, at that point. At the termination of twelve hours from the commencement of the trial, the stop valve will be shut, and the fires hauled. The exhibitor may, at his discretion, allow his fires to burn down toward the close of the trial; and will be credited, in any case, with the fuel remaining on the grate.

A Davis recording gauge, and, if possible, an Edson gauge, will be attached, and their record handed to the Committee at the close of each test.

The Committee will, at their own discretion, decline to proceed in any test where all the prescribed preliminaries have not been complied with; and will, should they consider it proper, throw out any test which has evidently not been conducted as directed.

After the trials all apparatus will be again tested, and measurements of heating and grate surfaces revised.

Very respectfully,

R. H. Thurston,

Chairman.

Supplementary Letter.

Fair of American Institute,

November 9th, 1871.

To the Superintendent of Machinery:

Sir,—It having been found necessary to change the position of the meter which is to measure the quantity of injection water used during the proposed test of steam boilers, and as it is now arranged so as to measure the entering stream, the following method of operation with respect to the supply of injection, etc., will be adopted:

At the beginning of each trial the injection will remain shut off until the temperature of the surface water in the tank has reached one hundred and fifty (150) degrees Fahrenheit, when the injection will be turned on.

At the close of the test, after the steam has ceased entering the condenser from the boiler on trial, the injection will remain open until it is found that the water entering and that leaving the tank have about the same temperature, and evidence is thus given that all of the heat received from the boiler has been taken away and meas

ured. During this latter interval, the temperatures of injection and of discharge will be measured at as frequent intervals as the Judges or their representatives may consider necessary for accurate determination of the quantity of heat passing off.

The tank for measuring the water of condensation having been found to leak seriously, you will substitute for it a vessel in which the water may be caught and accurately weighed.

You will see the precaution taken to open the injection cock as little as possible, in order to use the least quantity of water consistent with complete condensation of steam.

Very respectfully, yours,

R. H. THURSTON,

Chairman, for the Committee.

The Root boiler was first connected with the condenser, and its trial commenced, November 10th. But it was found that the boiler could furnish more steam than the safety-valve, through which the steam was intended to blow off into the condenser, could pass. It became necessary, therefore, to allow the steam to pass directly through a stop-valve into the condenser. This interrupted the trial for the day, and advantage was taken of the opportunity thus offered to remedy all of the minor defects that had been discovered.

On November 13th the trial of the Root boiler was made without mishap, continuing through twelve hours, as proposed; on the 14th the Allen boiler was tried; on the 15th the Phleger; and on the 16th the Lowe. After a series of mishaps, the Blanchard boiler was also finally tested successfully on November 21st.

We annex the record, given by the logs, in exhibits A, B, C, D and E.

* * * * * * * *

CALCULATIONS.

All calculations are given in detail, in exhibits F, G, H, I and J.

In calculating the results from the record of the logs, the Committee first determined the amount of heat caried away by the condensing water, by deducting the temperature at which it entered from that at which it passed off.

To this quantity is added the heat which was carried away by evaporation from the surface of the tank, as determined by placing a cup of water in the tank at the top of the condenser, at such height that the level of the water inside and outside the cup were the same, not-

ing the difference of temperatures of the water in the cup and at the overflow, and the loss by evaporation from the cup. The amount of evaporation from the surface of the water in the cup and in the condenser, which latter was exposed to the air, was considered as approximately proportional to the tension of vapor due their temperatures, and was so taken in the estimate. The excess of heat in the water of condensation over that in the feed water, also evidently came from the fuel, and this quantity was also added to those already mentioned.

The total quantities were, in thermal units, as follows:

Root, ...	34,072,058·09
Allen, ...	48,241,833·60
Phleger, ...	24,004,601·14
Lowe, ...	38,737,217·57
Blanchard, ...	11,951,002·10

These quantities being divided by the weight of combustible used in each boiler during the test, will give a measure of their relative economical efficiency; and divided by the number of square feet of heating surface, will indicate their relative capacity for making steam. But as it is the intention of the Committee to endeavor to establish a practically correct measure that shall serve as a standard of comparison in subsequent trials, it is advisable to correct these amounts by ascertaining how and where errors have entered, and introducing the proper correction.

There were two sources of error that are considered to have affected the result as above obtained. The tank being of wood, a considerable quantity of water entering it, leaked out again at the bottom, without increase of temperature, instead of passing through the tank and carrying away heat, as it is assumed to have done in the above calculation. The meters also have registered rather more water than actually passed through them, and this excess assists in making the above figures too high. The sum of these errors, the Committee, after a careful consideration of the several logs, and inspection of the apparatus, have estimated at four (4) *per centum* of the total quantity of heat carried away by the condensing water. The other two quantities are considered very nearly correct.

Making these deductions, we have the following as the total heat, in British thermal units, which was thrown into the condenser by each boiler:

Root, ...	32,751,834.34
Allen, ...	46,387,827.10

Phleger, ...	23,066,685.39
Lowe, ...	37,228,739.07
Blanchard, ...	11,485,777.35

That the figures thus obtained are very accurate, is shown by calculating the heat transferred to the condenser by the Root and the Allen boilers (both of which superheated their steam,) by basing the calculation on the temperature of the steam in the boiler as given by the thermometer, the results thus obtained being 32,723,681.76 and 46,483,322.5, respectively.

Dividing these totals by the pounds of combustible consumed by each boiler, we get, as the quantity of heat per pound, and as *a measure of the relative economic efficiency:*

Root, ...	10,281.53
Allen, ...	10,246.92
Phleger, ...	10,143.66
Lowe, ...	10,048.24
Blanchard, ...	10,964.94

Determining the weight, in pounds, of water evaporated per square foot of heating surface per hour, we get, as *a measure of the steaming capacity:*

Root, ...	2 65
Allen, ...	3.59
Phleger, ...	2.83
Lowe, ...	3.10
Blanchard, ...	1.92

It is but right to remark here that, as is indicated by the log, the fires in the Root boiler were allowed, at one time, to get much too low, and it is supposed that the standing of that boiler was thus seriously impaired. The fires of the Lowe boilers were undisturbed during the whole trial, its position, also, being thus lowered.

The quantity of heat per pound of combustible, as above determined, being divided by the latent heat of steam at 212° Fahr. (966°.6), gives, as *the equivalent evaporation of water at the pressure of the atmosphere, and with the feed at a temperature of* 212° *Fahr.:*

Root, ...	10.64
Allen, ...	10.60
Phleger, ...	10.49
Lowe, ...	10.40
Blanchard, ...	11.34

For general purposes, this is the most useful method of comparison for economy.

The above figures afford a means of comparison of the boilers, irrespective of the condition (wet or dry) of the steam furnished by them. All other things being equal, however, the Committee consider that boiler to excel which furnishes the dryest steam; provided that the superheating, if any, does not exceed about 100° Fahrenheit.

In this trial *the superheating* was as follows:

Root, ...	16°.08
Allen, ...	13°.23
Phleger, ...	0°.
Lowe, ...	0°.
Blanchard, ...	0°.

As the Blanchard, Phleger and the Lowe boilers did not superheat, it becomes an interesting and important problem to determine the quantity of water carried over by each with the steam. This we are able, by the method adopted, to determine with great facility and accuracy.

Each pound of saturated steam transferred to the condensing water the quantity of heat which had been required to raise it from the temperature of the water of condensation to that due to the pressure at which it left the boiler, *plus* the heat required to evaporate it at that temperature.

Each pound of water gives up only the quantity of heat required to raise it from the temperature of the water of condensation to that of the steam with which it is mingled.

The total amount of heat is made up of two quantities, therefore, and a very simple algebraic equation may be constructed, which shall express the condition of the problem:

Let H=heat units transferred per pound of steam.

h=heat units transferred per pound of water.

U=total quantity of heat transfered to condenser.

W=total weight of steam and water, or of feed water.

x=total weight of steam.

$W—x$=total weight of water primed.

Then $H\,x+h\,(W-x)=U$; or, $x=\dfrac{\frac{U}{h}-W}{\frac{H}{h}-1}$

Substituting the proper values in this equation, we determine *the absolute weights and per centages of steam and water* delivered by the several boilers to be as follows:

	Weight of steam.	Weight of water.	Per centage of water primed to water evaporated.
Root, . .	27,896.	0.	0.
Allen, . .	39,670.	0.	0.
Phleger, . .	19,782.94	645.06	3.26
Lowe, . .	31,663 35	2,336.65	6.9
Blanchard, . .	9,855.6	296.9	3.

And *the amount of water, in pounds, actually evaporated per pound of combustible:*

Root, ...	8.76
Allen, ...	8.76
Phleger, ...	8.70
Lowe, ...	8.55
Blanchard, ...	9.41

Comparing the above results, the Committee are enabled to state the following order of capacity and of economy, in the boilers exhibited, and their relative per centage of useful effect, as compared with the economical value of a steam boiler that should utilize all of the heat contained in the fuel:

	Steaming capacity.	Economy of fuel.	Per centage of economical effect.
Root, . .	No. 4	No. 2	0.709
Allen, . . .	" 1	" 3	0.707
Phleger, . .	" 3	" 4	0.699
Lowe, . . .	" 2	" 5	0.693
Blanchard, . .	" 5	" 1	0.756

The results obtained, as above, and other very useful determinations derived from this extremely interesting trial, are given in the following table, which the Committee hope and anticipate may be found, by all who are interested in the subject, to be of very great value as a reliable record of the trial of several excellent steam boilers, as a valuable *standard set of data* with which to compare the results of future trials, and as a useful aid in judging of the accuracy of statements made by boiler venders in the endeavor to effect sales by presenting extravagant claims of economy in fuel.

The Committee regret that the log of the trial of the Blanchard boiler was very carelessly kept, but they believe that the method adopted afforded such a perfect system of checks that no appreciable error was introduced.

They desire to express their appreciation of the neatness and efficiency of the arrangement by which provision is made, in the Lowe

Results of the competitive trial of Steam Boilers at the Fair of the American Institute, November, 1871.

NAME.	Square Feet.		Ratio of heating surface to the grate surface.	Total Weights.					Ratio of water primed to water evaporated.	Mean Temperatures.						
	Grate surface.	Heating surface.		Coal.	Combustible.	Feed.	Steam.	Primed water.		Injection.	Feed.	Water of condensation.	Discharge.	Steam.	Super heat.	Flues.
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.	P.
Root	27	876½	32.5	3800	3185.5	27896	27896	0.	0.	45°.94	45°.94	58°.31	113°.1	334°.6	16°.08	416°.6
Allen	32¼	920	28.5	537[illegible]	4527	39670	39670	0.	0.	45°.5	45°.5	63°.48	154°.76	330°.63	13°.23	345°.87
Phleger	23	600	26.1	2800	2274	20428	19782.94	645.06	3.26	45°.65	45°.65	54°.38	120°.83	321°.06	0°.	503°.76
Lowe	37¾	912	24.2	4400	3705	34000	31668.35	2336.65	6.9	45°.0	45°.0	54°.8	131°.5	319°.48	0°.	389°.6
Blanchard	8½	440	51.8	1232	1047.5	10152.5	9[illegible]5[illegible].6	296.9	3	44°.4	44°.4	49°.49	106°.14	323°.75	0°.	221°.67

Results, etc.—(Continued.)

NAME.	Total British thermal units.	Total units per pound of combustible.	Apparent Evaporation.				Actual Evaporation.		Equivalent evaporation of water at 212° Fahr. and atmospheric pressure.	Square feet of heating surface required to evaporate one cubic foot of water per hour.	Coal, lbs. per square foot, grate surface per hour.	Efficiency; actual evaporation of fuel divided by theoretical.
			Per pound of coal.	Per pound of combustible.	Per square foot grate surface per hour.	Per square foot of heating surface per hour.	Per pound of coal.	Per pound of combustible.				
	Q.	R.	S.	T.	U.	V.	W.	X.	Y.	Z.	Z. 1	Z. 2
Root,	32,751,834.34	10,281.53	7.34	8.76	86.09	2.65	7.34	8.76	10.64	23.59	11.73	0.709
Allen	46,387,827.1	10,246.92	7.38	8.76	102.51	3.59	7.38	8.76	10.60	17.41	13.88	0.707
Phleger	23,066,685.39	10,143.66	7.26	8.95	73.70	2.83	7.07	8.70	10.49	22.74	10.13	0.699
Lowe	37,228,739.072	10,048.24	7.68	9.12	75.06	3.10	7.20	8.55	10.40	21.63	9.71	0.693
Blanchard	11,485,777.35	10,964.94	8.24	9.69	99.53	1.92	8.00	9.41	11.34	33.48	12.10	0.756

boiler, for complete combustion of the furnace gases, and of the excellent general arrangement and proportions which gave to the Allen boiler its remarkable high steaming capacity.

As some authorities consider the evaporation of one cubic foot per hour to be the equivalent of one-horse power, column Z is introduced to give the area of heating surface required in each boiler, per horse-power, on this basis. *A good, modern steam engine* ought not to require more than one-half the specified amount.

The Committee conclude with an expression of the hope that the American Institute will make such tests of boilers a regular feature of its annual exhibitions, and that a standard set of apparatus, such as was here used, will be built, every possible precaution being taken to insure accuracy and delicacy in the instruments provided.

The Committee think that such action would confer a great benefit upon the country and upon the Institute, and that pecuniarily it would be also of advantage to the Institute, which should make a moderate charge to exhibitors for its use.

The report is signed by Professor R. H. THURSTON, Chairman; THOS. J. SLOAN and ROBERT WEIR.

WOOD-WORKING MACHINERY.

A treatise on its construction and application, with a history of its origin and progress. By J. RICHARDS, M. E.

(Continued from page 268).

Having in the preceding articles that have appeared in the *Journal* noticed, in succession, the popular machines in use for sawing, planing, cutting, boring, turning, etc., attention must in future be devoted to new machines, and to the progress of the "art," since these articles commenced.

Although not two years ago, the changes and improvements, both in this and foreign countries, has exceeded what was then predicted, and very fully confirms the position then assumed, as to the then imperfect character of machines of this class, when compared with engineering implements and manufacturing machinery generally.

In France, the manufacture of wood-cutting machines is, as a branch of engineering, quite as well developed as that of machines for cutting and shaping metal, a fact that is exceptional, and applies to no other part of the world. This is the more creditable when we consider that it is but ten years since the business was founded to an extent that

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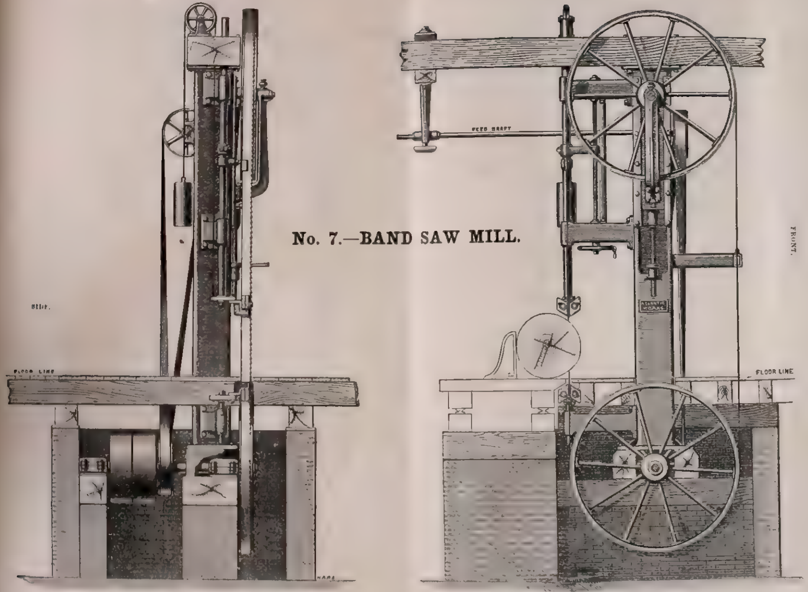
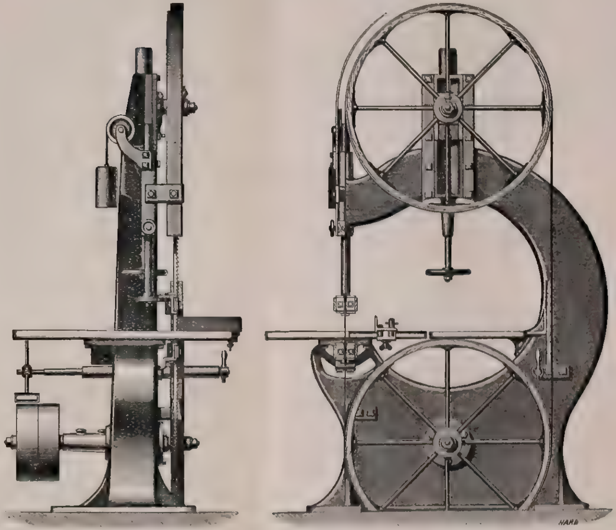
No. 7.—BAND SAW MILL.



No. 3—BAND SAWING MACHINE.



BUILT AT THE "ATLANTIC WORKS," PHILADELPHIA.

straight, curved or bevel lines by hand, and corresponds in its arrange-

entitled it to be called a branch of engineering, and to the farther fact that it is yet but a limited interest—compared to most other kinds of engineering work.

It should perhaps in this connection be explained that the manufacture of machinists' tools, with which we institute the comparison, has not kept pace with those of England and America. The highest talent in both these latter countries has, for nearly a half century past, been directed to the perfecting of machines for turning, planing, boring and shaping metals, and while the French have not been slow in following the precedents established, and have indeed added much, yet their progress has been but slow in comparison.

F. Arbey and M. Perin, of Paris, in their designs for wood-cutting machines, exhibit a boldness and originality that is not to be found among engineers in other branches. It is hoped that we will in time be able to give to the readers of the *Journal* some examples of the practice of M. Arbey, which will no doubt be of interest.

For engravings we present in this No., at fig. 1, true elevations of a Band Sawing Mill for timber drawn to a scale of $\frac{1}{48}$th $\frac{1}{4}''=1'$. The scale, it must be noticed, is a small one, and will, unless considered, convey an incorrect impression of the size of the machine, which is larger, with one exception, than any that has hitherto been made for this or any other purpose.

The wheels are of wrought iron, faced with wood, and covered with leather; their diameter over all being six feet. The blades are 45 feet long and five inches wide. The top shaft is supported both behind and in front of the top wheel; is of steel, three and a half inches in diameter. The lower shaft is four and a half inches diameter, with bearings twelve inches long. The guide stem is three and a half inches diameter, counterweighted, and carried in iron brackets bolted to the main column.

The mill is furnished either with feeding rolls for re-sawing lumber, or with a carriage for cutting timber, or with both, as may be wanted. The diagram on the right of the front elevation merely indicates the position of the log when arranged for timber-sawing. The engraving is intended only to illustrate the band-sawing mechanism. The vertical adjustment of the top wheel is twenty inches, with elastic tension of the blades to equalize the strain. Weight about three and one half tons.

Fig. 2, shows elevations of a new band-sawing machine for cutting straight, curved or bevel lines by hand, and corresponds in its arrange-

ment to our illustration in a former number, except that the throat is to the left instead of right hand, and that it is a much heavier machine. The wheels are 44 inches diameter, made of wrought iron and wood, the bearings are brass, shafts steel, and the whole fitted to meet the nice requirements of band-sawing. The scale is $\frac{1}{24}$th $\frac{1}{2}''=1'$; weight about one and one half tons.

These two examples are from the machines of Messrs. Richards, London, and Kelley, of this city.

EXPERIMENTS ON VARIOUS COALS OF THE CARBONIFEROUS AND CRETACEOUS PERIODS,

To Ascertain their Relative Potential and Economic Vaporizations. Made by Chief Engineer B. F. ISHERWOOD, *U. S. Navy, at the Mare Island Navy Yard, California, in* 1871.

The experiments described in this report on the vaporizative efficiencies of several kinds of coal, were made by the writer when he was Chief Engineer of the Mare Island Navy Yard, California, and embraced trials of all the varieties of which he could obtain a sufficient quantity. Previous to these experiments, nothing was known with regard to their relative value for steam generation, and the most erroneous opinions prevailed on the subject.

The coals experimented with belong to two geological periods, viz., the carboniferous and the cretaceous. Of the former are the anthracite from the Scranton mines, of Luzerne County, Pennsylvania, the Anthracitic coal from the western part of Wales, and the semi-bituminous coal from the Cumberland mines of Maryland. They are true coals, are extensively used, and have, for equal weights, the greatest steam-generating efficiency of any known, for which reasons they were experimented with to furnish a standard of comparison for the unknown coals of the latter period—a much more recent one than the carboniferous.

The coals of the cretaceous period experimented with, with the exception of the anthracite from Queen Charlotte Island, are what are called "brown coals." They are composed of exactly the same constituents as those of the carboniferous period, but in very different proportions; and these proportions vary, too, according as the coal belongs to the miocene or to the upper tertiary strata. To the latter belong the coals of Wyoming Territory and of California: while the remaining brown coals from Oregon, Washington Territory, Vancouver Island and Australia, belong to the former, and have their analo-

gues in the brown coals of Germany. The coal of Queen Charlotte Island is a brown coal transformed into anthracite by the heat and pressure of a mountain upheaval.

The coals of Vancouver Island, Washington Territory, Oregon and California, were from that portion of the Pacific Coast range of mountains which is comprised between British Columbia on the north and San Francisco on the south. Queen Charlotte Island lies off the northern part of British Columbia, and belongs to Great Britain. The coal of Wyoming Territory was from the Wahsatch Range or spur of the Rocky Mountains, and the mine is situate about 80 miles northeast of Great Salt Lake. The Australian coal was from the eastern coast of Australia, near Sidney, from which port in New South Wales it was shipped.

The following are the detailed descriptions of the different coals experimented with :

Pennsylvania Anthracite.

The specimen of this coal from the Scranton mines scarcely soiled the hand by contact, and possessed great cohesion, requiring strong blows from a hammer to break moderate-sized lumps. Its fracture was semi-conchoidal, the color a brilliant jet, the lustre almost metallic. It ignited with difficulty, burned slowly, and entirely by the surfaces, and gave out an intense heat. The lumps neither softened. swelled, nor agglutinated. At the commencement of the combustion there was a slight development of a very faint bluish flame, which soon passed to a faint yellow and quickly disappeared, leaving the incandescent fixed carbon alone. No smoke was at any time produced.

The following was the chemical composition of this anthracite in units of weight, *inclusive* of its hygrometric moisture, ash and clinker :

Carbon,	78·54
Hydrogen,	2.52
Oxygen,	1·68
Nitrogen,	0·84
Sulphur,	0·42
Hygrometric moisture,	1·16
Ash and clinker,	14·84
	100·00

Exclusive of hygrometric moisture, ash and clinker, the chemical composition in units of weight was as follows :

Carbon,	93·5
Hydrogen,	3·0
Oxygen,	2·0
Nitrogen,	1·0
Sulphur,	0.5
	100·00

The specific gravity of this anthracite was 1·453.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 70 per centum were ash and 30 per centum clinker. The specific gravity of the clinker was 1·931.

One cubic foot of this anthracite in the merchantable state weighed 58·82 pounds, of which bulk the solid matter occupied 64·89 per centum and the interstitial spaces 35·11 per centum. To stow one ton of this coal, 38·08 cubic feet are required.

One cubic foot of the ash weighed 56·47 pounds; and one cubic foot of the clinker weighed 40·00.

Queen Charlotte Island Anthracite.

The anthracite from Queen Charlotte Island, off the northern portion of the Pacific coast of British Columbia, was identical in chemical composition with the Scranton anthracite, excepting the proportion of earthy matter, which was greatly larger. In appearance, mechanical properties, and mode of combustion in the furnace, it was exactly like the Scranton anthracite. The following was its chemical composition in units of weight, *inclusive* of its hygrometric moisture, ash and clinker:

Carbon,	55·54
Hydrogen,	1·78
Oxygen,	1·19
Nitrogen,	0·59
Sulphur,	0·30
Hygrometric moisture,	0·85
Ash and clinker,	39·75
	100·00

The specific gravity of this anthracite was 1·508.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 63·53 per centum were ash, and 86·47 per centum clinker. The specific gravity of the clinker was 2·052.

One cubic foot of this anthracite in the merchantable state weighed 64·70 pounds, of which bulk the solid matter occupied 68·77 per centum, and the interstitial spaces 31·23 per centum. To stow one ton of this coal 34·62 cubic feet are required.

One cubic foot of the ash weighed 51·41 pounds; and one cubic foot of the clinker weighed 46·35 pounds.

Welsh Anthracite.

The anthracitic coal from the western portion of Wales, was intermediate in its characteristics between anthracite and semi-bituminous coal. It was lamellated of alternate streaks of dull black and shining jet; the latter streaks exactly resembling anthracite, being hard and not soiling the hand; while the former streaks resembled semi-bituminous coal, being moderately friable and easily soiling the hand. This coal kindled with difficulty, and burned even more slowly than the anthracite, but with more flame, which was, however, of a faint yellowish color, and entirely free of smoke. The lumps did not intumesce or cohere, but they did not preserve their form as completely as in the case of the anthracite.

The following was the chemical composition of this coal in units of weight, *exclusive* of its hygrometric moisture, ash and clinker:

Carbon,	91·5
Hydrogen,	4·0
Oxygen,	2·5
Nitrogen,	1.0
Sulphur,	1·0
	100·0

Inclusive of hygrometric moisture, ash and clinker, the chemical composition in units of weight was as follows:

Carbon,	84·18
Hydrogen,	3·68
Oxygen,	2·30
Nitrogen,	0·92
Sulphur,	0·92
Hygrometric moisture,	1·27
Ash and clinker,	6·73
	100·00

The specific gravity of this anthracitic coal was 1·390.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 85·16 per centum were ash, and 14·84 per centum clinker.

One cubic foot of this coal in the merchantable state weighed 56·85 pounds, of which bulk the solid matter occupied 65·55 per centum, and the interstitial spaces 34·45 per centum. To stow one ton of this coal 39·40 cubic feet are required.

One cubic foot of the ash weighed 34·60 pounds.

Semi-Bituminous Coal.

The semi-bituminous coal experimented with, was from the Cumberland mines of Maryland. It ignited readily, and burned freely with a red flame of medium length, giving off a moderate quantity of semi-transparent brown smoke. It contained but a small amount of volatile matter, which was soon expelled, and the remaining mass quickly acquired the temperature of full ignition. The lumps of this coal, while parting with their volatile elements, lost their shape, agglutinated slightly, and intumesced considerably, forming a very porous coke, which underwent rapid and complete combustion. This coal, by reason of at first slightly cohering in the furnace, needed, at the commencement of its combustion, occasional breaking up on top with the firing-tools.

The physical structure of the semi-bituminous coal is chiefly columnar, passing sometimes into slaty. The columnar portions are semi-crystalline, while the slaty ones are amorphous; the former exhibit a deep shining jet, the latter are dull black. The cohesion is weak; the slightest blow causes fracture, the surface of which is frequently striated, and in all casts much soils the hand. The smallest mechanical action crumbles the lumps into fine powder.

The following was the chemical composition of this coal in units of weight, *inclusive* of its hygrometric moisture, ash and clinker:

Carbon, ...	80·55
Hydrogen, ...	4·50
Oxygen, ...	2·70
Nitrogen, ...	1·08
Sulphur, ...	1·17
Hygrometric moisture, ...	1·75
Ash and clinker, ...	8·25
	100·00

Exclusive of hygrometric moisture, ash and clinker, the chemical composition in units of weight was as follows:

Carbon, ...	89·5
Hydrogen, ...	5·0
Oxygen, ...	3·0
Nitrogen, ...	1·2
Sulphur, ...	1·3
	100·0

The specific gravity of this semi-bituminous coal was 1·332.

Of the earthy matter remaining after combustion, and composed of

ash and clinker, 85·16 per centum were ash, and 14·84 per centum clinker. The specific gravity of the clinker was 1·820.

One cubic foot of this semi-bituminous coal in the merchantable state weighed 55·65 pounds, of which bulk the solid matter occupied 66·97 per centum, and the interstitial spaces 33·03 per centum. To stow one ton of this coal, 40·25 cubic feet are required.

One cubic foot of the ash weighed 32·00 pounds; and one cubic foot of the clinker weighed 38·85.

Brown Coal.

The name of brown coal is given to the fossil carbonaceous deposits of the cretaceous period, which are of more remote origin, and have been subjected to greater heat and pressure than the lignites. This coal cannot be discriminated by the eye from the true coals or those of the carboniferous period, from which they differ principally in their larger proportion of oxygen and hygrometric moisture, in which respect they seem to occupy an intermediate position between the lignites and true coals, though even among the brown coals the proportion of oxygen and moisture varies considerably.

Of the brown coals experimented with, that of Australia more nearly approached the true coals in chemical composition; after which came the Nanaimo coal from Vancouver Island, and the Bellingham Bay coal. The remainder were identical with each other in chemical composition, exclusive of ash and hygrometric moisture, the latter varying slightly.

All the brown coals experimented with were alike in their physical characteristics and in their behavior in the furnace. They ignited with facility and burned with much rapidity, giving off copious volumes of heavy black smoke, from which the soot fell in a shower of flakes. During combustion, the lumps swelled slightly, lost their form, and coked, but did not agglutinate; the flame was long, very dense, and yellowish-white.

Brown coal divides into cubical lumps, which have a considerable degree of hardness, so that a smart blow from a hammer is required to break them. They have a coarse-grained appearance, and a very irregular fracture not in the least conchoidal. They are composed of thin laminæ, and present a dull grayish black color, soiling the hand much by contact. When subjected to heat, they quickly fall into very small pieces, which escape between the grate-bars, unless those spaces are made very narrow.

Australian Brown Coal.

Two samples of Australian brown coal were experimented with. The "first sample" was of very superior quality; the "second sample" was a fair average of what is supplied to the market. The difference in their caloric effect was very great; for, in the "first sample," it exceeded that in the "second sample" 18½ per centum, The following is the chemical composition of the two samples in units of weight, *inclusive* of hygrometric moisture, ash and clinker :

	First Sample.	Second Sample.
Carbon, ...	74·02	64·25
Hydrogen, ...	4·78	4·15
Oxygen, ...	7·47	10·00
Nitrogen, ...	1·11	1.00
Sulphur, ...	0·62	0·60
Hygrometric moisture, ...	3·93	10·00
Ash and clinker, ...	8·07	10·00
	100·00	100·00

Exclusive of hygrometric moisture, ash and clinker, the chemical composition in units of weight was as follows :

	First Sample.	Second Sample.
Carbon, ...	84·11	80·31
Hydrogen, ...	5·43	5·19
Oxygen, ...	8.49	12·50
Nitrogen, ...	1·56	1·25
Sulphur, ...	0·71	0·75
	100·00	100·00

The specific gravity of the Australian brown coal was 1·275.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 64·22 per centum were ash, and 35·78 per centum clinker. The specific gravity of the clinker was 1·852.

One cubic foot of this brown coal in the merchantable state weighed 54·12 pounds, of which bulk the solid matter occupied 68·04 per centum and the interstitial spaces 31·96 per centum. To stow one ton of this coal, 41·39 cubic feet are required.

One cubic foot of the ash weighed 34·50 pounds; and one cubic foot of the clinker weighed 40·24 pounds.

BROWN COAL FROM THE WAHSATCH RANGE OF THE ROCKY MOUNTAINS; FROM THE MOUNT DIABLO MINES OF CALIFORNIA; FROM COOSE BAY, OREGON; AND FROM SEATTLE, ON PUGET SOUND, WASHINGTON TERRITORY.

The brown coals from the Wahsatch Range of the Rocky Mountains in Wyoming Territory; from the mines of Mount Diablo, in California; from Coose Bay, in Oregon; and from Seattle, on Puget Sound, in Washington Territory, had identically the same chemical composition, exclusive of hygrometric moisture, ash and clinker, in which latter particulars they slightly varied.

Their chemical composition, *exclusive* of hygrometric moisture, ash and clinker, were as follows, in units of weight:

Carbon,	71·5
Hydrogen,	5·5
Oxygen,	19·5
Nitrogen,	1·3
Sulphur,	2·2
	100·0

The following is their mean chemical composition in units of weight, *inclusive* of hygrometric moisture, ash and clinker, namely:

Carbon,	50.05
Hydrogen,	3·85
Oxygen,	13·65
Nitrogen,	0·91
Sulphur,	1·54
Hygrometric moisture,	16·82
Ash and clinker,	13·18
	100·00

The specific gravity of these brown coals was 1·320.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 69·18 per centum were ash, and 30·82 per centum were clinker. The specific gravity of the clinker was 1·774.

One cubic foot of these brown coals in the merchantable state weighed 53·36 pounds, of which bulk the solid matter occupied 64·79 per centum, and the interstitial spaces 35·21 per centum. To stow one ton of these coals, 41·98 cubic feet are required.

One cubic foot of the ash weighed 39·41 pounds; and one cubic foot of the clinker weighed 37·73 pounds.

BROWN COAL FROM BELLINGHAM BAY, WASHINGTON TERRITORY.

The brown coal of Bellingham Bay is the extreme northwest corner of Washington Territory, immediately opposite the Nanaimo

mines of Vancouver Island, from which it is separated by a narrow strait of water. Though but another part of the Nanaimo vein, the Bellingham Bay coal is inferior in calorific value to that from those mines, principally because it is a surface coal, and contains, consequently, a much greater proportion of hygrometric moisture, ash and clinker, while the Nanaimo mines have been long worked, and to a very considerable depth. The chemical composition of both coals, *exclusive* of the hygrometric moisture, ash and clinker, is exactly the same, and as follows, in units of weight, namely:

Carbon,	75·5
Hydrogen,	5·3
Oxygen,	14·0
Nitrogen,	1·3
Sulphur,	1·9
	100·0

The chemical composition of the Bellingham Bay coal, *inclusive* of its hygrometric moisture, ash and clinker, is as follows, in units of weight, namely:

Carbon,	49·60
Hydrogen,	3·39
Oxygen,	8·96
Nitrogen,	0·83
Sulphur,	1·22
Hygrometric moisture,	12.52
Ash and clinker,	23·48
	100·00

The specific gravity of the Bellingham Bay coal was 1·350.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 72·35 per centum were ash, and 27·65 per centum clinker. The specific gravity of the clinker was 1·794.

One cubic foot of this brown coal in the merchantable state weighed 60·70 pounds, of which bulk the solid matter occupied 72·07 per centum, and the interstitial spaces 27·93 per centum. To stow one ton of this coal 36·90 cubic feet are required.

One cubic foot of the ash weighed 39·00 pounds; and one cubic foot of the clinker weighed 32·00 pounds.

Nanaimo Brown Coal.

This coal is from the Nanaimo mines, on the southeastern portion of Vancouver Island, British Columbia, and about seventy miles north of the city of Victoria. These mines (1871) are three in number.

One is on a small island called Newcastle Island, separated from Vancouver Island by a strait about one-eighth of a mile wide; the other two, called No. 3 Pit and Parkhead Level and Slope, are on Vancouver. Only the Newcastle Island mine has been extensively worked, and from it came the coal on which the experiments were made.

The physical character of the clinker of this coal varied greatly with the rate of combustion. At the maximum rate (18.397 pounds of coal per square foot of grate surface per hour), the clinker was very fusible and highly vitreous, running down between the grate-bars into the ash-pit in the consistence of stiff tar, and cooling there to a jet black glossy substance, very brittle, and highly conchoidal in fracture. This clinker when on the grates was of tarry stickiness, and very difficult of removal by the slice-bar. At the medium rate of combustion (12,642 pounds of coal per square foot of grate surface per hour), the character of the clinker entirely changed; it lost its vitreous appearance and tarry consistency, came easily from the grate-bars when hot, and was no longer fusible. At this rate of combustion, the clinker was no more objectionable than that from the best steam-coals.

The chemical composition of the Nanaimo coal, *exclusive* of the hygrometric moisture, ash and clinker, is as follows, in units of weight, namely:

Carbon,	77·5
Hydrogen,	5·3
Oxygen,	14·0
Nitrogen,	1·3
Sulphur,	1·9
	100·0

The chemical composition of the Nanaimo coal, *inclusive* of the hygrometric moisture, ash and clinker, are as follows, in units of weight, namely:

Carbon,	59·68
Hydrogen,	4·08
Oxygen,	10·78
Nitrogen,	1·00
Sulphur,	1·46
Hygrometric moisture,	10·26
Ash and clinker,	12·74
	100·00

The specific gravity of the Nanaimo coal was 1·302.

Of the earthy matter remaining after combustion, and composed of ash and clinker, 59·54 per centum were ash and 40·46 per centum clinker. The specific gravity of the clinker from the maximum rate of combustion was 2·279 ; and from the medium rate of combustion, 2·444.

One cubic foot of the Nanaimo coal in the merchantable state weighed 51·77 pounds, of which bulk the solid matter occupied 63·73 per centum, and the interstitial spaces 36·27 per centum. To stow one ton of this coal, 43·27 cubic feet are required.

One cubic foot of the ash weighed 48·71 pounds. One cubic foot of the clinker from the maximum rate of combustion weighed 51·53 pounds ; and one cubic foot of the clinker from the medium rate of combustion weighed 43·77 pounds.

Coke from the Nanaimo Coal.

The brown coals are very iuferior producers of coke and illuminating gas, to the semi-bituminous and bituminous coals of the carboniferous period ; and the inferiority is in both quantity and quality. The coke experimented with was made from the Nanaimo coal by subjecting it to destructive distillation in the retorts of the San Francisco gas works. It was extremely porous, very hygrometric, not very hard, and amounted in weight to 43 per centum of the coal from which it was made. It contained 13·85 per centum of ash and clinker, and 13 per centum of hygrometric moisture, by weight. The specific gravity of the coke was 0·868.

Of the earthy matter remaining after combustion, and eomposed of ash and clinker, 47·79 per centum were ash, and 52·21 per centum clinker. The specific gravity of the clinker was 2·488.

One cubic foot of this coke in the merchantable state weighed 28 pounds, of which bulk the solid matter occupied 51·70 per centum, and the interstitial spaces 48·30 per centum. To stow one ton of this coke, 80 cubic feet are required.

One cubic foot of the ash weighed 44·47 pounds ; and one cubic foot of the clinker weighed 48·70 pounds.

The experiments on the coals and coke above described were made with the spare boiler for supplying the machine-shop engine ; the description of which, as well as the plan of the experiments, will follow in subsequent numbers.

THE GUNPOWDER PILE DRIVER.

(Report upon its Operation at the New Landing Wharf at League Island.)

By F. C. Prindle, C. E.

Editor of Journal of the Franklin Institute :

Dear Sir—I am now able to respond to your request, and so redeem my promise to give you the results of my experience with Shaw's Gunpowder Pile Driver during its operation here in driving the piles of our new landing wharf, which part of the work has recently been completed.

From the novel application of gunpowder to pile driving, and the wide spread interest felt in the results of its practical operation in actual work, not to mention the many advantages claimed for it by its inventor, I was led at the outset to keep a complete record of its operations here, and which has been noted down on the spot by a constant and careful observer.

The wharf in process of construction is located at the foot of Broad street, and extends into the Delaware 300 feet from the embankment, by 100 feet wide, crossing the mean low-water line about half way out.

The bearing piles, which are of heavy yellow pine, are spaced 8 feet between centres lengthwise and 5 feet crosswise—the specifications requiring them to average 10 inches middle diameter, and to be firmly driven to hard bottom.

The whole number driven was 807, including mooring piles, and particular care was taken to preserve the alignment of all the rows crosswise and the outer row on each side lengthwise.

They were driven through a soft mud, containing some clay, to a very hard bottom, where they brought up firmly, and which required from six to eight "blows," with heavy charges of powder to penetrate before they could be forced any further, and then but with difficulty. This stratum—supposed to be hard clay or compact gravel—was met the whole distance, and at a nearly uniform depth of about 21 feet below mean low water.

The machine used was an entirely new one, and in some respects an experimental one, and was operated by the contractors with inexperienced hands chiefly. It was secured to a large scow in the usual manner, the latter also carrying a small engine to hoist the piles in position.

The gun, weighing 1800 lbs., has a $6\frac{1}{4}''$ bore, $24''$ deep, pointing

upwards, and is recessed at the lower end to receive the head of the pile, upon which it rests.

The ram, weighing 1300 lbs., moves in the same guides as the gun, and is provided with a piston, projecting from its lower end and neatly fitting into the bore of the gun, its upper end having a bore of greater diameter to receive a fixed piston secured to the top of the frame, and thus form an air cushion to prevent its escape from the guides when the height of its rebound is limited, as during the first blow with very long piles. The ram is caught and held at its highest ascent, and also released for the succeeding blow by the operation of a friction brake at one side pressing it against the opposite guide—all at the will of the operator on deck.

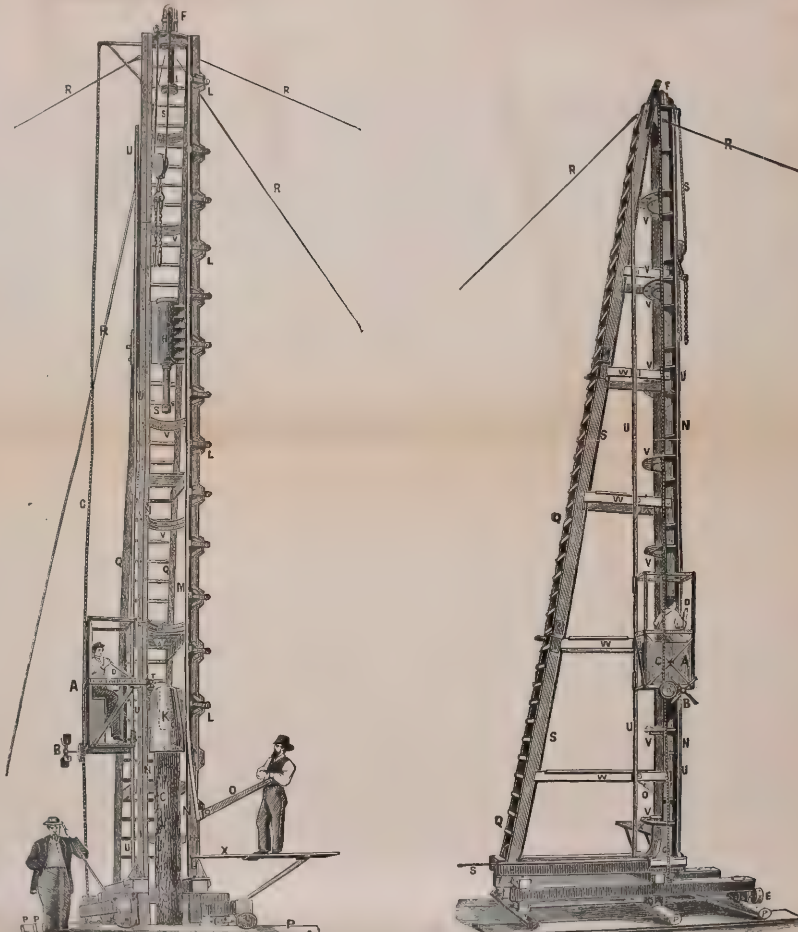
The cartridges used were made of a slow powder, cylindrical in shape ($1\frac{1}{4}''$ diameter and from $1''$ to $1\frac{1}{2}''$ long), weighing from one to one and one-half ounce each, and slightly coated with paraffine.

The first blow was generally given using an ounce cartridge, and the remainder with $1\frac{1}{4}$ or $1\frac{1}{2}$ ounce, according to size of pile, the cartridges being supplied by hand and tossed into the gun in advance of each blow.

The operation of driving is as follows: The engine hoists the ram, gun and pile into position simultaneously, with one movement; the brake is then applied, holding the ram in place, uppermost, and the gun and pile are then lowered together until the pile rests in the mud; the gun is then lowered on the top of the pile, the recess securely holding the pile-head in place directly underneath.

A cartridge is then dropped in the gun, the operator releases the brake and the ram falls with its piston entering the bore of the gun (which is made slightly funnel-shaped at the muzzle), and by compressing the air exerts a gradually increasing downward pressure upon gun and pile till the inertia of both is more or less entirely overcome, the cartridge is crushed by the pistcn, and ignited by the heat evolved by the sudden and severe compression of the confined air. An explosion immediately ensues, the result of which is to violently force the pile downward, and this is measured by the reactionary effort upon the ram,—the height to which it is thus thrown, and from a state of rest, practically, I suppose. The force due to the fall of the ram and the explosive force exerted to throw it again in position are thus at once combined and applied to the pile.

The principal difference of effect between this method and the ordinary hammer appears to be just here: in the one case the pile is



SHAW'S GUNPOWDER PILE DRIVER.

TABLE I.

Number of Pile.	Diameter. Inches. Bottom.	Top.	Length of Pile. Ft	Depth driven. Ft.	Distance last blow. In.	Rebound of Ram. Ft.	Number of Blows.	Weight of Cartridge. Final. Ounces. 1	1¼	1½	Number of Cartridges used. Ounces. 1	1¼	1½	Time. H. M.	Da
					Row	No	20.								18
					Actu	*al W*	*ork.*							P.M.	Ja
1	10	14	37	21	0	12	7		1		1	6		1.00	1
					Row	No.	21.								
1	9	13	36	21	1	11	7		1		1	6		1.24	‘
2	9	12	32	21	6	10	5		1		1	4		1.47	‘
3	9	13	35	21	1	12	5		1		1	4		1.54	‘
4	9	15	35	21	0	13	8		1		1	7		2.02	‘
5	9	13	34	21	1	12	6		1		1	5		2 07	‘
6	9	14	35	21	1	12	6		1		1	5		2.12	‘
7	9	14	35	21	4	12	6		1		1	5		2.17	‘
8	9	14	35	21	2	13	8		1		1	7		2.21	‘
9	8	12½	35	21	6	10	6		1		1	5		2.26	‘
10	9	13	35	21	3	12	6		1		1	5		2.33	‘
11	9	13	34	21	4	10	5		1		1	4		2.38	‘
12	10	16	35	21	1	12	9		1		1	8		2 45	‘
13	10	15	36	21	2	12	8		1		1	7		2.50	‘
14	10	13	36	21	0	11	6		1		1	5		2.54	‘
15	10	16	35	21	0	13	8		1		1	7		2.58	‘
16	10	15	36	21	0	12	9		1		1	8		3.03	‘
17	9	13	35	21	0	12	6		1		1	5		3.07	‘
18	10	15	35	21	3	13	8		1		1	7		3.11	‘
19	9	13	34	21	2	12	8		1		1	7		3.15	‘
20	10	15	35	21	6	12	6		1		1	5		3.20	‘
21	10	15	35	21	1	13	7		1		1	6		3.25	‘
					Row	No.	22								
21	10	15	34	21	0	12	7		1		1	6		3 33	‘
20	10	15	34	21	0	13	10		1		1	9		3.55	‘
19	10	15	35	21	4	12	7		1		1	6		4 03	‘
18	9	13	35	21	1	13	7		1		1	6		4 09	‘
17	9	14	35	21	1	12	8	1			4	4		4.15	‘
					Row	No.	32							A.M.	M
3	9	14	34	18	0	13	5		1		1	4		7.39	3
4	9	13	40	18	0	14	5		1		1	4		7.54	
5	9	16	37	18	1	14	5		1		1	4		8.00	
6	10	16	35	18	1	13	6		1		1	5		8.14	
7	10	16	35	18	0	15	6		1		1	5		8 35	
8	8	12	30	18	12	13	3		1		1	2		8.44	
9	9	12	30	18	20	12	3		1		1	2		9.00	
10	10	16	38	18	0	14	5		1		1	4		9.06	
11	10	14	36	18	0	15	5		1		1	4		9.17	
12	9	13	38	17½	2	14	4		1		1	3		9.27	
13	10	15	39	17½	1	14	6		1		1	5		9.42	
14	11	17	36	18⅛	1	14	15		1		1	14		9 53	
15	10	15	35	17½	0	16	5		1		1	4		10 05	
16	10	14	38	17½	0	15	6		1		1	5		10.16	
17	9	14	36	17½	1	14	5		1		1	4		10.23	
18	9	15	36	17½	1	15	6		1		1	5		10.33	
"Mooring Pile."	9	16	38½	17½	0	15	8		1		1	7		10 46	
19	9	16	35	17½	1	14	7		1		1	6		10.55	
20	11	16	40	17½	0	15	11		1		1	10		11.08	
21	10	16	35	17½	0	14	7		1		1	6		11.16	

TABLE I.—Continued.

mber of Pile.	Diameter. Inches. Bottom.	Top.	Length of Pile. Ft	Depth driven. Ft.	Distance last blow. In.	Rebound of Ram Ft.	Number of Blows.	Weight of Cartridge. Final. Ounces. 1	$1\frac{1}{4}$	$1\frac{1}{2}$	Number of Cartridges used. Ounces. 1	$1\frac{1}{4}$	$1\frac{1}{2}$	Time H. M.	Date.
					Row	No.	33.								1872.
21	10	16	37	$17\frac{1}{2}$	0	15	7		1		1	6		A.M. 11.30	Mar. 30
20	12	18	37	$17\frac{1}{2}$	0	14	11		1		1	10		P.M. 12.13	"
19	9	13	35	$17\frac{1}{2}$	0	15	4		1		1	3		1.10	"
18	9	14	35	$17\frac{1}{2}$	3	14	6		1		1	5		1.34	"
17	9	14	35	17	0	14	5		1		1	4		1.40	"
16	9	14	35	17	0	13	5		1		1	4		1.43	"
15	9	14	34	17	1	13	5		1		1	4		2.00	"
14	9	14	35	17	0	13	5		1		1	4		2.04	"
13	9	13	35	17	4	12	4		1		1	3		2.13	"
12	9	14	34	17	1	13	5		1		1	4		2.20	"
11	10	15	35	17	3	14	8		1		1	7		2.30	"
10	9	14	35	17	4	13	4		1		1	3		2.38	"
9	9	$13\frac{1}{2}$	34	17	2	13	4		1		1	3		2.43	"
8	9	13	40	17	1	14	4		1		1	3		2.50	"
7	9	13	32	17	4	13	4		1		1	3		2.56	"
6	10	14	34	17	0	14	6		1		1	5		3.08	"
5	9	14	35	17	1	13	4		1		1	3		3.13	"
4	10	14	35	17	4	12	5		1		1	4		3.18	"
3	10	15	35	17	0	14	6		1		1	5		3.22	"
2	10	14	$31\frac{1}{2}$	17	0	14	10		1		1	9		3.30	"
1	9	15	35	17	0	15	10		1		1	9		3.40	"
					Row	No.	34.								
1	9	15	36	17	0	16	9		1		1	8		4.15	"
2	9	15	36	17	0	16	6			1	1		5	4.35	"
3	9	14	36	17	0	17	4			1	1		3	4.43	"
4	9	13	32	17	20	15	3			1	1		2	4.52	"
5	9	14	40	$16\frac{1}{2}$	0	17	4			1	1		3	5.12	"
6	10	15	36	$16\frac{1}{2}$	0	14	5			1	1		4	5.19	"
7	9	14	36	$16\frac{1}{2}$	0	15	5			1	1		4	5.24	"
8	9	14	36	$16\frac{1}{2}$	0	14	4			1	1		3	5.29	"
9	9	14	35	$16\frac{1}{2}$	0	15	5			1	1		4	5.33	"

TABLE II.

Diameter Inches. Bottom.	Top	Length. Ft.	Height of fall Ram. Ft.	Depth driven by Impact. In.	Depth driven next blow by Explosion. Inches	Weight of Cartridge. Oz.	Height of rebound of Ram Feet.	Remarks.
				Experimental.				
8	13	35	15	6	30	1	9	2d and 3d blows upon pile.
8	12	35	15	3	12	1	9	3d " 4th " " "
8	$13\frac{1}{2}$	35	18	1	8	1	9	5th " 6th " " " Pile 12 ft. below surface.
9	$12\frac{1}{2}$	35	20	$2\frac{1}{2}$	12	$1\frac{1}{4}$	17	5th & 6th blows upon pile. Block crushed to pieces.

he impact was obtained by letting ram fall upon heavy oak block placed over mouth un. The rebound of ram after explosion was generally somewhat retarded by a arly application of the piston brake.

already in motion when a tremendous force is suddenly brought to bear upon it in the same direction, and in the other case it receives a violent blow when at rest and a considerable portion of the force is expended uselessly in the destruction of the pile-head itself before its inertia is overcome and motion produced. Hence the necessity of strongly banding the pile-heads in the latter case, and the utter absence of any necessity for their protection in the former.

The ram on its rebound is caught and held by the brake, and the operation repeated at pleasure.

The following record of each pile driven was kept, viz.: Diameter at top, diameter at bottom, length, depth driven, distance driven at last blow, height of rebound of ram, number of blows, number and weight of cartridges used, do. of last cartridge, and the time.

I have not yet had time to carefully summarize the whole record, but will furnish you with a complete copy, if you desire it. I enclose you, however, a copy of the record for January 13th, when 12 piles were driven in a single hour, under favorable circumstances; also for March 30th, when 50 were driven in a single day.*

Some of the smaller piles were driven to hard bottom with 3 blows, but generally required from 5 to 8 blows, according to size; and in some instances as many as 15 blows were necessary to penetrate the hard bottom. The piles were all driven without the slightest injury, and none of them showed any marks of violence.

The work began Nov. 9th last, and continued, with several interruptions, unil Dec. 4th, when it was suspended for the winter. It was again commenced Jan. 12th, but after a few hours' work on the 12th and 13th it was again suspended, on account of the cold weather, until March 15th, when the work was resumed, and completed April 4th.

The total working time, as per record, foots up 187 hours, making an average of only 4·3 piles driven per hour. Considerable loss of time was occasioned, however, in waiting for piles, and by sundry vexatious delays incident to the operation of a new machine with inexperienced workmen, and the shoal water also caused considerable interruption by the grounding of the scow.

In fact, the conditions of weather, shoal water, supply of piles, &c., unfortunately proved unfavorable for a full exhibition of its

*The complete record has been requested, and will be published in a succeeding number.—Ed.

power when working up to its capacity for several days in succession without interruption, and I am therefore disappointed in being unable to obtain such a record.

Average depth actually driven, 19·4 feet; average number of "blows" per pile, 5·2; average weight of powder per pile, 8·2 ounces.

The largest number driven in any one hour was 12, as before stated, and 50 in any one day.

To demonstrate the efficiency of this method as compared with the ordinary method of driving piles, I caused several experiments to be made by letting the ram fall upon a heavy oak block placed over the muzzle of the gun to receive its blow, like an ordinary hammer, noting the effect, and then following it with explosion of a cartridge, and noting its effect. The result was in favor of the new method in the ratio of from 4 to 1, to 8 to 1, as shown by the enclosed record of the experiments.

There is no doubt of the entire practicability of this novel method of driving piles, as well as of its great superiority. Greater penetration can be secured and with much greater ease than in the ordinary process; no banding or protection whatever is required for the pile-heads; no loss of any portion of the pile from injury, and the pile is infallibly guided home without assistance, saving time and avoiding all risk of accident in this respect, while the rapidity of its action coupled with the enormous pressure of its "blows," and without the slightest injury to the pile, I believe to be unequalled by any process.

Some defects of construction in this machine have been developed by this trial, and which have operated to prevent its entirely successful operation, but which can be easily remedied in another.

Government Aid to Science.—We learn that a number of scientific gentlemen connected with the Smithsonian Institution and the Naval Observatory have united in a memorial to Congress, urging upon it the appropriation of a liberal sum ($150,000) to be devoted to thoroughly organizing expeditions for the observation of the approaching transit of Venus. The number and importance of the astronomical questions which it is hoped this event will enable astronomers to definitively settle, cause it to be awaited as a celestial phenomenon more eventful than any that have occurred for many years. There is every reason to hope that the same intelligent interest and support which has thus far been manifested by our government in scientific work, and which have won for us the admiring comments of the scientific fraternity abroad, will enable our expeditions to go forth fully equipped and able to compete with those of other lands.

Chemistry, Physics, Technology, etc.

CONTRIBUTIONS TO THE SUBJECT OF BINOCULAR VISION.

By Prof. Chas. F. Himes, Ph. D.

(Continued from page 356.)

Chimenti Pictures.

Subsequently to the publication of his book,* from which the preceding quotations have been made, Sir David Brewster introduced the so-called Chimenti Pictures into the controversy. It happened that Dr. Crum Brown, of London, about 1869, during a visit to Lille, noticed two plane line drawings, apparently perfect fac similes, hung side by side in the same frame. The subject, as given in fig. 10, which is a copy of the right hand picture, is a man sitting on a stool, having a pair of compasses in one hand and a string in the other; their size about 12½ inches high by 8½ inches wide; their reported author the artist Chimenti. He thought that, by convergence of the optic axes upon them, he obtained stereoscopic relief by their combination, and reported the fact to Sir David Brewster. It was only after personal application of Prince Albert to the Emperor Napoleon that permission was granted to photograph these pictures. They were soon thereafter placed before the public in the form of an ordinary stereograph, with a descriptive label, embodying the opinion of Sir David, that the pictures constituted a true stereograph, and that it was the intention of the artist that they should do so. They became at once the subject of animated discussion; some experts with the stereoscope attributing true stereoscopic effect to them, and others as decidedly denying it.

Fig 10.

* "The Stereoscope," London, 1856.

Casting out of the controversy these apparently conflicting opinions, founded simply on inspection by means of the stereoscope, careful measurement and comparison of the distances between identical points of the foreground with those between identical points of the background, showed that there should indeed be a mixed stereoscopic and pseudoscopic effect; for the variation in these distances did not follow the rule given in the preceding pages for the production of stereographs, since they did not increase, for all points, in passing from points in the foreground to those in the background. Thus, whilst some points, intended to appear in front, were nearer together than others, intended to appear more remote; on the other hand, some points, which it was just as evident were intended to appear in the foreground, were further apart than others as clearly in the background. Thus, a portion of the dress overhanging the left knee seems, in the stereoscope, to try to recede behind the knee, and on measurement, the distance between corresponding points of the folds of the dress is found to be *greater* than that between corresponding points of the knee. So the distances between corresponding points in the line of the back, in the two pictures, from the girdle to the lapel on the left shoulder, are less than the distance between the tops of the left knees, giving that line a tendency, when the pictures are viewed in the stereoscope, to take a position in front of the knees—evidently a pseudoscopic effect. A complete analysis made of the pictures in this way, by careful measurement, one of the most exhaustive having been made by Professor Emerson, shows that it matters little indeed which of the two pictures he assumed as the right-eye picture, except that, by one arrangement of them, there may be a preponderance of stereoscopic over pseudoscopic effect, which, with the other criteria of the picture, might, in a casual or inexperienced observer, create the impresssion of true stereoscopic effect of the whole, and easily account for the conflicting opinions, rendered in the earlier stages of the controversy, after simple inspection in the stereoscope. Some, as would be most natural, seem to have been influenced most by the points that were truly stereoscopic, whilst others, observing more closely, and perhaps with less bias, saw decided symptoms of unnatural, pseudoscopic effect. It is plain that careful measurement, as before given, alone was competent to decide the question as to the purpose of these pictures, and since it revealed such conflicting stereoscopic data throughout, it remained hardly supposable that any artist of reputation could have designed them as companion binocular pictures, much less that

he could have designed them to be united in some way or other to produce an impression of relief. Besides, the pictures, on careful measurement, did not prove to be identical in size, one being about one-half inch larger than the other.

It seems, therefore, that one is most probably a copy of the other; that the differences are purely accidental, and such as are unavoidable in copying, and that, therefore, when compared, the difference in distances of corresponding points is sometimes on the side of stereoscopic effect, and at other times on the side of pseudoscopic effect. Thus, any copy of a drawing, however carefully executed, and of course of the same size, will form with the original a stereograph, similar in effect to the Chimenti Pictures, to a greater or less degree of mixed effect. It has indeed been proposed, among the numerous applications of the stereoscope, to employ it for the detection of counterfeit bank notes, by comparing a suspected one, in the stereoscope, with a genuine one as a complementary picture, in which case the minutest differences in engraving would cause some parts, or letters, &c., to appear in front of, or behind, the plane of the paper. It would, of course, require considerable experience in the use of the stereoscope to render it available in such cases. The remaining arguments in favor of the stereoscopic character of these pictures, and consequent antiquity of the stereoscope, are summed up in the following remarks of Sir David Brewster: "The stereoscopic pictures have been preserved as the work of Chimenti himself, and the historian of science will naturally ask what led so eminent an artist to make so uninteresting a sketch as that of a man sitting on a stool, with a pair of compasses in one hand and a string in the other. He will ask what led him to make a copy of it of the very same size, and without any change or improvement whatever. He will ask what led him to preserve such uninteresting sketches. But, above all, he will ask, with a peculiar interest, what led him *to place these two figures side by side*, and in such manner that the instant they were seen by an intelligent traveller, Dr. Crum Brown, he conceived that they were intended to be brought into relief by binocular vision, and actually brought them into stereoscopic relief by retiring and combining the two separate pictures. The historian of science will not even be satisfied with the obvious answers to these questions. He will inquire into the *date* of these drawings, and he will be struck with the fact that they were executed at the time when Baptista Porta had called the attention of philosophers to the subject of binocular vision, and

had shown, in a diagram so far resembling a stereoscopic slide, that external objects—that is, objects in relief—were seen binocularly by the combination of a right- and left-eye picture of them. He will also connect with these facts, though he may not give it much weight, the statement of Prof. Archer, the distinguished director of the Industrial Museum of Scotland, 'that just before he left Liverpool, in a turn-out of the Museum there, *what appeared to be a stereoscope was found*, bearing the date of 1670.' 'Being out of order,' he adds, 'it was laid aside at the time, and probably had not been touched since.' 'It appeared,' he said, 'to be of *Roman* manufacture; and he suggested that an attempt should be made to get it for examination, as having an important bearing on the subject before the Society, namely, the subject of Chimenti's stereoscopic figures.' In forming his opinion from these various considerations, the historian of science will not fail to notice that the binocular theory of Baptista Porta was published in *Italy*, in 1593; that the stereoscopic drawings, which so wonderfully illustrate it, were also made in *Italy* some time after this, between 1620 and 1640; and that the probable stereoscope in Liverpool, with the date 1670, is considered to be of *Italian* origin."

Many of the arguments involved in the above have already been disposed of. That drawn from the assumption that the pictures are by Chimenti, by him arranged side by side, with some design, etc., loses much of its force, when the fact is considered that the pictures in the Museum at Lille were part of the plunder of Napoleon I; that these pictures are only *presumed* to be by Chimenti on account of their style, and that they were most likely placed side by side in the arrangement of the pictures in the gallery, because they were alike.

The account of the Liverpool stereoscope is almost Pickwickian, and only merits notice on account of Sir David's connection with it. Suffice to say that, upon more careful examination, it turned out to be a somewhat peculiar binocular telescope, with the date 1726 upon it.

Object of the Stereoscope.

The object of the stereoscopic instrument is frequently most conveniently stated, in a general way, to be the apparent superposition of the two dissimilar pictures of a stereograph, so as to enable any one to combine them readily, and receive from them a single resultant impression of a body in relief. For the sake of convenience such statements are allowable, but the part that any kind of stereoscopic instrument plays, will be much more fully comprehended by recalling

the difficulty involved in viewing such dissimilar pictures by the *unaided eyes* so as to obtain the impression of relief, and remembering, at the same time, that it is this difficulty that the instrument is intended to obviate. The eyes, in any of the methods for combining the pictures without the aid of an instrument, as stated in the discussion of these methods, must be accommodated for distinct vision to the plane of the paper on which the pictures are drawn, whilst the axes, contrary to unvarying habit, must be converged to a point more remote, according to one method, or to a nearer point, according to the other ; and the dissociation of these invariably associated optical adjustments constitutes the great difficulty which the stereoscope, of whatever construction, is intended to remove, by so bending the rays of light emanating from the pictures, that they may seem to the eyes, properly placed, to be in the same place.

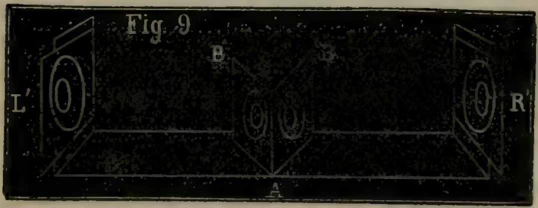
It will be sufficient to examine how this is accomplished in the two principal forms of the instrument, namely, the reflecting stereoscope, proposed by Professor Wheatstone, and having therefore an additional historic interest, and the refracting or lenticular stereoscope, devised by Sir David Brewster, which has come into such general use, and which, probably more than any other, is generally suggested by the word stereoscope.

Wheatstone's Reflecting Stereoscope.

Fig. 8.

Mirrors were employed in this instrument. Their arrangement and application belongs to elementary optics. Thus, fig. 8, AB and AB′ represent sections of two plane mirrors, placed at right angles to each other. A ray of light, emanating from an object at R′, a wafer, for example, on striking the mirror AB, would be reflected toward R, and, according to the laws of reflection of light, the object would appear, to an eye placed at R, to be located at C, in the direction of the reflected ray, on the line drawn perpendicular to the mirror from R′,

and as far behind the mirror on that line as R′ is in front of it. Movement of the object R′, along the line on which it is placed, it is evident, would change the position of C, the location of its virtual image. For the same reason, a wafer can be placed on L′ so that its image should appear to be at C, to an eye placed at L, after reflection from the mirror AB′. If complementary pictures are substituted for wafers, and R and L represent the right- and left-eye respectively, it is plain that these pictures would appear to be located at the same place, or be superposed; *the optic axes would be converged, and the eyes adjusted focally to points in the same plane*, the cause of the difficulty before alluded to will have been removed.



By inspection of fig. 9, the form and use of the instrument will more fully appear. On the vertical frames L′ and R′ are grooves, in which the left- and right-eye pictures are slid, as those of the frustum of the cone represented in the figure. The face is brought close up against the board, represented by the dotted line, placed along the line of junction of the two mirrors, AB, AB′, each of these being about four inches square. The eyes will then be in position to have their proper pictures presented to them. The pictures are then moved back and forth in the grooves until, apparently, complete superposition is effected, when the figure will immediately start out in relief. The pictures will coincide, more or less perfectly, in different positions, but the finest effect is only produced when they occupy similar positions relative to their respective mirrors. The upright frames, on which the pictures are slid, were also connected by a right- and left-handed screw, so that they could readily be made to approach or to recede from each other, thus permitting a variation of the distance of the pictures from the mirrors.

This form of stereoscope has some advantages over the next to be mentioned, especially in the fact that the size of the pictures to be employed is not as restricted, and that the same pictures may be employed pseudoscopically, since they are on separate cards, but it is plain that, on account of the lateral inversion in images formed by plane mirrors, which causes an officer, for example, to appear to hold his sword in his left hand, the pictures, in order to produce a proper effect, must be

drawn with this lateral inversion, or they must be transparent, so that they can be placed before the mirrors in either position. It is also apparent that the form of the instrument is not as compact, nor in any way as convenient, as that of the common lenticular stereoscope, and that, in viewing transparencies, it would require two lights of equal intensity, one behind each picture.

In explaining the action of the stereoscope, it is not necessary, however, to regard the simple apparent superposition of the pictures, as the cause of the appearance of relief, since this fact may be explained on the same theory as that adopted for the explanation of the perception of relief in the objects themselves, in the sections on *Binocular Vision*, and subsequently, namely, that of the movement of the optic axes in passing from the view of one point, in case of the real object, or of identical points, in case of pictures, to another point, or other identical points of the pictures, nearer or more remote. For the superposition of the pictures cannot, in the nature of the case, be perfect, on account of the dissimilarity of the pictures, so that, if they are adjusted so that identical points of the foreground in the pictures coincide, identical points in the background will necessarily not coincide, and the more remote the points represented the greater the want of coincidence. The eyes, however, take this up, and readily cause these points to coincide in turn, in running over the pictures, by slightly decreasing the convergence of the optic axes, by rolling the eyes outward,—a movement similar to that required in passing to objects in the background, in viewing the objects themselves, and consequently producing the same mental impression of increased distance or relief.

THE GREAT FIRES OF 1871 IN THE NORTHWEST.

By Prof. I. A. Lapham,

Asst. to Chief Signal Officer U. S. A.

1st Paper.

The great fires that have recently spread, with such disastrous results, over our whole northern frontier, from the Rocky Mountains to central New York and Pennsylvania, must be regarded as the effect of meteorological causes. Unusual dryness has pervaded the atmosphere during the past two months; the amount of rainfall has been very considerably less than the average and the amount of evapora-

tion considerably more.* Very little rain has fallen upon most of this extended region since August.

Winds from a south-westerly direction, blowing often with great force and for several days continuously, bring to the great prairie region of the West this excessive dryness. Their prevalence is often shown by the direction towards which the trees lean ; they absorb moisture from every source, making everything of a combustible nature still more combustible. The soil itself becomes desiccated to a considerable depth. Pine lumber, of which houses, barns, fences, &c., are made, becomes excessively inflammable. The weeds and grass of the prairies and stacks of hay and grain are deprived of all moisture, and partake of the nature of tinder.

When these winds are blowing, a small spark is sufficient to kindle a great fire; the camp fire, the wad from a gun, a spark from a locomotive, even the remnant of a cigar, or the ashes from a pipe, may start a fire that will spread over a county. A stroke of lightning has, doubtless, been the origin of many a prairie fire. The Indians are said to have purposely set them on fire to rout the deer and other game.

The violent wind hastens to spread the flame over a constantly widening space, until large districts are laid waste by the "destroying element." It is familiarly known that these fires have annually spread over the great prairie region of the Mississippi Valley since their first exploration. Prairie fires are no new thing. Of course they vary in extent from year to year, according to the varying dryness of the seasons and other meteorological causes. A smoky atmosphere in autumn has been the common experience every year; and this smokiness has its origin in prairie fires at the West.

The fire once started in the dry grass and weeds of the prairie cannot be extinguished; it must take its own course, gradually widening as it moves forward, until it presents a front of a hundred miles or more; and the flames, often reaching a great height, are blown forward, setting fire to places many rods ahead.

These fires do not kill the roots of the prairie grass, which springs up fresh from the blackened soil, when its proper season returns; but the germs of other plants, including all forest trees, are destroyed.

When these fires reach the borders of the forest region the trees

* Rain at Milwaukee in September: Maximum (1841) 7·02 inches, mean of twenty-nine years 2·88—minimum (1871) 0·60.

are attacked, and many of them destroyed; others are more or less injured. The young shoots are killed; the roots beneath the soil, and in many cases even the soil itself is consumed.

It is when the south-west wind is high, and the atmosphere dry, and when, from long absence of rain, the vegetation is also dry, that we are to look for these great prairie fires.

We thus have before us the true theory of the origin of the prairies; they are clearly due to the dryness of the climate in autumn and the consequent fires. Their existence is not due to the effect of dryness of climate upon the growth of trees themselves, for, when protected from fires, trees are found to flourish in the prairie region. It is by fire (induced by dryness) that the trees are destroyed or prevented from growing.

These conditions of climate, the autumnal dryness and the prevalence of south-west winds, have existed for ages, and hence the normal condition of the great western plains is that of prairie; and so long as these causes exist, this region must always remain in this condition, unless changed by ingenious and persistently applied devices of art.

The normal condition of other regions is that of forest growth. When old fields are abandoned within these forest regions, as in Virginia, &c., or wherever lakes have been drained, a growth of trees immediately takes possession of the soil. In a few years the forests have resumed their possession.

Within the prairie region the soil is equally well adapted to the growth of trees, and, by continued effort in the prevention of fires, they may soon be made to cover the land with their grateful shade, their beauty and their usefulness; but should these efforts be discontinued for a few years, *the dry weather*, the *high winds* and the *accidental fires* will surely do their appointed work, and the prairie grass will resume its possession of the ground. The normal condition of prairie will again be established.

The northern boundary of the region of prairie forms a line which varies from year to year as the seasons vary. A continued succession of dry seasons encourages great fires, that penetrate the forest border and extend the area of the prairie; while a similar succession of wet seasons may allow a growth of trees to spread far within the proper boundaries of the prairie. A constant struggle is thus maintained between the two conditions of forest and prairie, alternating within certain limits, and changing the position of the dividing line. It is

here that we find the "openings," or scattered trees, chiefly of the burr-oak (*Quercus macrocarpa*), which give so much park-like beauty to the landscape.

The work of extending the prairie border was exhibited in the autumn of 1871 upon the grandest scale. Fires have swept more or less completely along the whole northern frontier, from the Rocky Mountains through Dakota, Minnesota, Wisconsin and Michigan, and even into New York and Pennsylvania.

Within the past two or three decades this region has been occupied and "improved;" farms have been opened; mills built, especially throughout the "lumber region" or places where the stately white pine (*Pinus strobus*) predominates. Villages, large towns, and even great cities have sprung up along this prairie border line with a rapidity truly wonderful. And now it is found that these natural, ever recurring meteorological causes which have for so many ages prevented the growth of forest trees, are equally operative in preventing the *building of houses, towns and cities.*

Not only has the wild prairie region been swept by the fires of 1871, but thousands of square miles of forests have been destroyed. Many farms, with their houses, barns, stacks of hay and grain, miles of fences, &c., have been destroyed. At the same time a number of towns and a large part of the city of Chicago were consumed, involving the loss of many thousand human lives. The ground upon which these improvements were made has been reduced to the normal condition of prairie.

It becomes apparent then, that if we wish to occupy and improve this prairie region, to cover it with villages, towns and cities, to cultivate its rich and productive soil, we must contend against this natural law, which constantly and surely tends to assert its power to reduce everything to its former normal condition. To do this will require more than individual effort—only united and enforced, or in other words governmental effort can afford hope of success.

The precautions necessary to resist this destruction of property are of the simplest kind, being only such as are necessary to prevent the occurrence and spread of fire. This involves not only watchfulness, but the disuse, as far as possible, of all combustible materials. The watchfulness should extend not only to our own premises, but to prevent the carelessness and criminality of others; which can only be done by public authority. The use of kerosene in all its forms should be prohibited; no locomotive should be allowed to move without ade

quate means to prevent the emission of sparks from the smoke stack, and no fences of wood should be built. If the farmers of France, Germany, &c., can do without fences, certainly we can do the same, and thus save not only this food for the fires, but one-half of the aggregate capital required in the conduct of our agriculture! A thousand other measures, needless here to mention, should be adopted and *enforced*, looking to the same end.

It is announced that some farmers who have "lost their all" by these fires have become disheartened and discouraged, and will entirely abandon their possessions. If this is done now, while everything is fresh and new, while the soil retains its virgin richness, what may we expect in after years? Gradually, but surely, the whole country will be reduced (as have been the once fertile plains of the East) to the condition of a desert. It is true this may be in the distant future, but it is nevertheless our duty to prevent this result, so far as it is within our power.

If fences could be dispensed with, and if our houses could be constructed of materials other than wood, the very great destruction of our forests, now going on with such fearful rapidity, would be checked. It is estimated that fifty years will suffice to consume the pine lumber of Wisconsin and Michigan, the chief present sources of supply; the time therefore is close at hand when the forests will no longer supply the lumber used in temporary construction, erected only to increase the danger of great public calamities by fire!

Should the present policy be continued, the destruction of a large share of the newly built railroad stations in the prairie region of the West will surely come; they are built in opposition to the law of the land, a law that sooner or later must be enforced. A dry season, a strong wind and an accidental fire, whenever they occur together, will do the work.

If these views be correct, it is apparent that the precautions against these greater calamities are most needed at the south-west part of the town or city; here is always the place of greatest safety, and here should be erected buildings for the preservation of the most precious records and works of art, which, if lost, cannot be restored. Had the fire of Chicago originated at the north or east side of the city, the barn in which the kerosene lamp was kicked over alone would have been burned.

Milwaukee, Wis., Oct. 26, 1871.

SPECTROSCOPIC NOTES.

By John H. Leach.

(Communicated by Professor C. A. Young.)

Although Fr. Secchi and others have recently published descriptions of the different varieties of solar prominences which have been observed, well illustrating the many forms in which these outbursts from the sun's chromosphere occur, a careful record of such disturbances as may be out of the more common order may in the end assist us to a farther knowledge on this subject.

While looking for bright lines near F in the spectrum of a low prominence situated 25° north of east, at 11.35 A.M. (April 2d), my attention was called to what appeared to me a sudden displacement of the F line toward the violet end of the spectrum.

I immediately brought the C line into the field of view, in order to discover if any change was taking place in the form of the prominence, but was wholly unprepared for the spectacle which met my eye. Upon widening the slit I found that where only twenty minutes before there had been a comparatively low mass of prominence matter, not exceeding 50″ in height, and remarkable only for the brightness of a jet issuing from the southern portion which was but slightly raised above the chromosphere, there had been an eruption of matter on a grand scale.

Fig. 1 represents the prominence as first seen at 11.15 A. M.. At 11.35 A.M. the northern portion had entirely disappeared, and from the low mound, at the point where the jet mentioned above had been seen, an eruption had taken place far exceeding anything I have ever witnessed. Far above the chromosphere the air was filled with long wisps of glowing hydrogen, ranging from 20″ to 50″ (seconds) in length, with the appearance of having been ejected in quick succession. Above them floated detached masses, in the form of thin fleecy clouds, and the highest point reached by these was fully five minutes of arc, or about 135,000 miles above the sun. In the mound appeared a low, sharp horn, exceeding in brightness any other portion of the prominence. The grandeur of the eruption lasted but a few minutes, gradually fading in brightness and diminishing in size.

Fig. 2 gives a correct idea of the general form and extent of the prominence as seen at 12 M.

When next observed, at 1.40 P.M., nothing was left but a small

Fig. 1.
11.15. A.M. April 2. 1872.

Fig. 2.
12. M. April 2. 1872.

Fig. 3.
1.40. P.M. April 2. 1872.

Fig. 4.
2 P.M. April 2. 1872.

Fig. 5.
2.20. P.M. April 2. 1872.

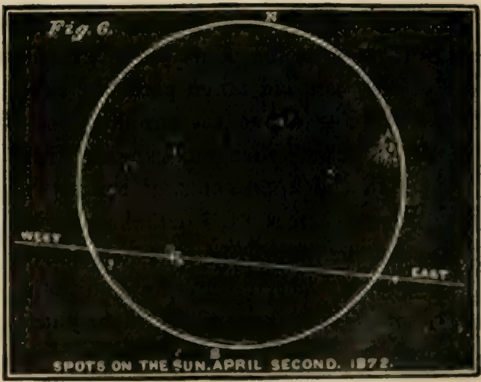


Fig. 6.
SPOTS ON THE SUN. APRIL SECOND. 1872.

cloud mass of about the height of the prominence when first seen, at 11.15 A.M. To the north of this, however, were two very small horns, of great brightness. It has generally been noticed that the appearance of these bright points in the chromosphere is a forerunner of increased activity. The forces at work beneath were only gathering strength for a final outburst, which, if not so great in extent, proved to be equally magnificent. I had not long to wait, for after a few minutes spent in examining the F line, just as the clock was striking the hour I again brought C into the field, and found myself only in season for the grand finale. The chromosphere had again belched forth, and far above the sun could be seen the ejected matter, reaching to the height of 94,500 miles. The débris was in the form of jets or wisps, which appeared to be falling toward the chromosphere, here and there fretted with sharp horns or bristles. The remains of the first eruption existed unchanged since last seen, at 1.40 P.M., but the changes in the form of the new one were rapid; at one point the filaments were so interlaced as to resemble close network. In the more elevated portions the jets soon lost their brilliancy, and in less than an hour scarcely anything remained but a few stray wisps floating low down near the chromosphere.

Fig. 5 exhibits the change which the last outburst had undergone at 2.20 P.M.

During the phenomena the C and F lines were completely broken up, being displaced toward both the red and violet ends of the spectrum, the greatest displacement being toward the violet, in the F line extending to the iron line above F numbered 2082 in Kirchoff's map. The D_3 line also suffered a sensible displacement. I examined the magnetic needle during the outbursts and an hour afterwards, but could detect no unusual disturbance. In the evening there was a slight auroral display.

The portion of the chromosphere in which the eruptions took place was in the neighborhood of a group of spots which were just making their appearance upon the eastern limb of the sun. The spots were completely surrounded by faculæ which radiated from the spots themselves, and could be traced to the sun's edge. Fig. 6 shows the position of the spots upon the sun at the time of the eruptions. The sketches were made at the time of observation, and are as correct as the duration of the phenomena would allow, the general form and most of the details being preserved.

ON HALLEY'S COMET.

By Prof. Daniel Kirkwood.*

The distinguished astronomer, Mr. Hind, has traced back the returns of Halley's comet to the year 11 B.C. He remarks, however, that previous to that epoch, "the Chinese descriptions of comets are too vague to aid us in tracing any more ancient appearances," and that "European writers of these remote times render us no assistance." It is now proposed to inquire whether the comet had probably made any former approach to the sun in an orbit nearly identical with the present.

It is well known that the modern period is considerably less than the ancient. Thus, the mean period since A.D. 1456—the first return recognized by Halley—has been 75·88 years; while from 11 B.C. to 1456 A.D. it was 77·27 years. In determining the approximate dates of former returns, the ancient period should evidently be employed. Now, it is a remarkable fact that of more than seventy comets,† or objects supposed to be comets, whose appearance was recorded during the six centuries immediately preceding the year 11 B.C., but one—that of 166 B.C.—was observed at a date corresponding nearly to that of a former return of Halley's comet. Of this object it is merely recorded that "a torch was seen in the heavens." Whether this was a comet or some other phenomenon, it is impossible to determine. But the comet of Halley was more brilliant in ancient than in modern times. It seems, therefore, extremely improbable that seven consecutive returns of so conspicuous an object should have been unrecorded, especially as twelve comets per century‡ were observed during the same period. It would seem, therefore, that the perihelion passage of the year 11 B. C. was the first ever made by the comet, or at least the first in an orbit nearly the same as the present.

In a paper read before the American Philosophical Society, November 19th, 1869, it was shown that the aphelion distances of the comets of short period are nearly equal to the distances of the major planets Jupiter, Saturn, Uranus and Neptune; and that most of the comets now moving in elliptic orbits probably owe their periodicity to the

* Read (by title) at the Indianapolis Meeting of the American Association, August, 1871.

† See the Catalogues of Chambers and Williams.

‡ The average number.

disturbing action of these planets. The aphelion of Halley's comet, it must be confessed, is so remote from the plane of the ecliptic that Neptune's disturbing influence would be but feeble. Possibly, however, the *original* position of the orbit may have been considerably changed. It is an interesting question whether the difference between the ancient and the modern elements of the comet are chiefly due to the defective data, or to real changes produced by the planets. Burckhardt's elements for 989 A.D. make the longitude of the ascending node precisely coincident with that of the aphelion; while the present difference is about 69 degrees. If it be granted that the transformation of the orbit was produced by Neptune, at what epoch could the change have been effected? In other words, at what time before the Christian era was the comet in the vicinity of its aphelion when Neptune had nearly the same longitude? It is certainly remarkable that for a thousand years preceding the passage of 11 B.C., there was but one such epoch of maximum disturbance, and that this occurred about 50 B.C.

A NEW LANTERN-GALVANOMETER.

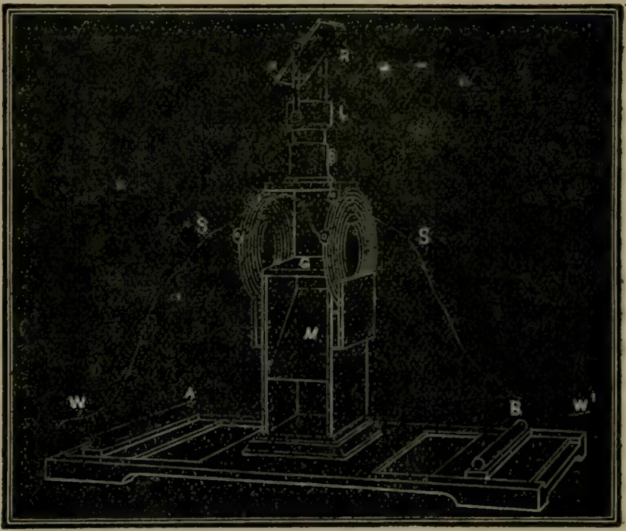
By Alfred M. Mayer, Ph. D.,

Professor of Physics in the Stevens Institute of Technology, Hoboken, N. J.

On the 21st of December, 1871, I delivered a lecture on "The Earth a Great Magnet"* before the American Institute, at the Academy of Music, in the city of New York. In the experimental discussion I then made of the earth's magnetism, it was necessary to use a galvanometer so constructed that the deflections of its needle would be visible to a large audience. At the same time, the astatic condition of this needle had to be so controlled that it could be readily altered during the progress of the lecture, and an arrangement of damping magnets had to be devised that would permit me instantly to bring the needle into the magnetic meridian, when disturbed therefrom whenever I set in action the large electro-magnet used on that occasion. Indeed one of the principal uses to which this galvanometer was applied in the lecture was the exploration of the magnetic condition of the space surrounding this electro-magnet. This I accomplished by rotating wire coils at various distances and positions around the magnet and leading the induced magneto-electric currents through the galvanometer.

* In course of publication by Charles C. Chatfield & Co., New Haven.

The lantern-galvanometer, which I will now proceed to describe, was devised on the 13th of last November, and as it has accomplished all that I desired I think that its service in the lecture room warrants this formal description of it.



Referring to the figure, M is a plane mirror, inclined 45° to the vertical. In front of this and quite close to it are the back condensing lenses of an oxyhydrogen lantern. The front lens of the condenser is placed *above* the mirror at G. The back condensing lenses are of such curvatures that when the calcium light is placed about two inches from the one nearest it, a beam of light of nearly parallel rays issues from them to fall upon M; thence to be reflected to the upper condensing lens at G. This arrangement of lenses is due to President Morton, of the Stevens Institute of Technology, and gives a bright and uniformly illuminated field, free from color.* Resting on G is a

* "The original idea and general plan of the instrument [' the vertical-lantern '] shown was, as the speaker (Prof. Morton) stated, due to Professor J. P. Cooke, of Cambridge, his own work in connection with it being confined to the devising of a convenient mechanical arrangement of parts, the improvement of the combination of condensing lenses with the reflecting mirror so as to secure a white and evenly illuminated field on the screen, and the discovery that an ordinary silvered mirror would serve for the final reflection as efficiently as a metal speculum or glass silvered by Foucault's plan, which are so difficult to obtain or keep in order."—*Quarterly Journal of Science*, October, 1871.

disc of glass, on whose border is photographed a divided circle. In the centre of this glass disc is a low needle point on which freely rotates a magnetic needle. Above the needle is the projecting lens L, the pencils from which are reflected in any desired direction by means of the plane mirror R, which rotates on a horizontal axis and has also a motion in azimuth around the axis of the lens. The horizontal condensing lens G has a diameter of five inches and the magnetic needle is four inches long.

To deflect this needle by an electric current I place as close to the condenser as possible the two spirals S and S′ formed of $\frac{1}{10}$ inch wire of *square section*, so as to bring the convolutions as close as possible. The turns of the spirals are separated by very thin vulcanite ribbon coated with paraffine; the spirals are wrapped on vulcanite discs and have an internal diameter of four inches and an external diameter of ten inches, and each contains about 49 feet of wire. The spirals are so placed on the sides of the condenser that a line joining their centres passes through the centre of the magnetic needle.

The vertical-lantern rests upon a base-board, 3 feet 6 inches long, with guides on its sides, between which slide boards carrying the two bar magnets A and B, each 15 inches long and 1 inch in diameter of section. These magnets cannot only approach to and recede from the lantern, and thus vary their distances from the galvanometer needle, but they can also rotate around their centres on vertical axes. Thus, the poles of the base-magnets being similarly placed with those of the galvanometer needle they render it more or less astatic as they are nearer to or further away from it. Also, in case the needle should not come to the meridian on moving the base-magnets, it can be made to do so by rotating about a vertical axis one or both magnets; and thus, also, can be neutralized any exterior disturbances tending to deflect the needle from the magnetic meridian.

The galvanometer-needle may also be rendered astatic by suspending it from above by a silk fibre and attaching to the needle a wire which descends through a hole in the condenser and in the inclined mirror and carries beneath the latter another magnetic needle with its poles reversed. In this arrangement we move the base-magnets to a greater distance and render the combination astatic by their action on the lower needle.

In working with thermal currents a smaller needle and condenser, allowing the coils to approach each other, can be used; but for the detection and measurement of currents of thermo-electricity it is

better to coil close around the upper needle a wire in a flat coil of only one wire in breadth. Thus the thickness of the surrounding coil need not exceed the breadth of the needle, and its image on the screen will form a single zero point.

I will now give a few experiments serving to show the usefulness of this instrument.

Experiment 1. A coil of $2\frac{1}{2}$ feet in diameter, containing 40 turns of 300 feet of $\frac{1}{10}$ inch copper wire, was placed with its plane at right angles to the line of "the dip." The terminals were connected with the galvanometer, whose needle was rendered nearly astatic by means of the two damping magnets. I now rotated the coil quickly through 180° around an axis at right angles to the line of the dip. The needle was deflected about 12°.

Exp. 2. The two cores of the large electro-magnet of the Stevens Institute of Technology were placed end to end, thus making one iron bar of 7 feet in length and of 6 inches in diameter. This was surrounded with its 8 bobbins, containing in all 2000 feet of $\frac{1}{5}$ inch copper wire. Through this was sent the electricity developed by the the most advantageous combination of 60 plates of zinc and carbon, 8×10 inches.

A coil of 20 inches in diameter of one turn of $\frac{1}{5}$ inch wire was rotated around a vertical axis, $3\frac{1}{2}$ feet distant from one pole of the core; the galvanometer needle moved over 3°.

Exp. 3. Same as exp. 2, *except* there were 5 turns of $\frac{1}{10}$ inch wire in the coil of 20 ins. diam. Deflection = 30°.

Exp. 4. A coil of 20 inches in diameter, formed of 20 turns of $\frac{1}{10}$ inch wire, was rotated through 180° around a vertical axis, $6\frac{1}{2}$ feet distant from the pole of the magnet. Deflection = 22°.

Exp. 5. Same as exp. 4, but rotated coil with its centre 3 feet 8 inches above the equator of the magnet. Deflection = 80°.

Exp. 6. A coil of $2\frac{1}{2}$ feet in diameter of 40 turns of 300 feet of $\frac{1}{10}$ inch wire was rotated with its centre 28 feet distant from equator of magnet. Deflection = 20°.

Exp. 7. The following experiments will show the excellent proportions of the coil used in Exp. 6 for the evolution and study of induced terrestrial magneto-electric currents:

I placed this coil on a table and connected its terminals with a galvanometer, such as is used in studying thermo-electric currents. The needles of this galvanometer made one vibration in nine seconds. On lifting the E side of this coil 6 inches, the galvanometer needle

was deflected 10°. Lifting the same side 9 inches the needle went to 22°. Placing the coil in a vertical N. and S. plane and suddenly tilting its top 6 inches to the E. or towards the W., the needles were deflected 60°. Tilting the top 9 inches sent the needles with a blow against the stops at 90°.

THE UTILIZATION OF THE LIGHT PETROLEUM OILS.

By William H. Wahl.

(A Paper read before the Optical Section of the Franklin Institute, March 28th, 1872.)

Amongst the problems which have taxed the ingenuity of practical minds for years, that of increasing the source and supply of illuminating agents ranks with the most important. The necessity for their increasing excellence and cheapness grows more urgent as our civilization advances, and it is scarcely to be doubted that the resources of science will prove equal to the demands to which she has given origin. The history, indeed, of the last half century furnishes an instructive illustration of the assertion, and will afford the future chronicler of human events a theme of unequalled richness; for his will be the record of a time in which such prodigious strides were made in every department of human knowledge, that it will stand alone an epoch-making period in the material progress of our race.

Not the least interesting of the items which go to make up the sum of our century's progress, is the development of the modes and appliances for procuring artificial illumination.

When the needs of increased culture first made an illuminating agent necessary, the torch, doubtless, furnished the material. Then followed probably the torch steeped in resinous substances; and the simple lamps, from which the heavy animal and vegetable oils were burned; then the candle was introduced. Then, in quite recent times, came the introduction of burning gas from coal; and finally, though it had doubtless been used in isolated localities for centuries before, came the general introduction of petroleum and its products.

In our own time, the needs of commerce have called for illumination of great intensity, which science has furnished in the oxycalcium, the magnesium and the electric lights. These have, however, for obvious reasons, but limited application, and as their general introduction for the purposes of the household is out of the question, they

only concern the purpose of this sketch as items in the history of the subject of illuminating agents.

Quite recently, indeed within the past few years, attempts have been made to increase the efficiency of the ordinary illuminating gas, by passing it through a well of some volatile liquid hydro-carbon ; the process being termed super-carburetting. This plan has been slightly varied by mixing with the gases, before combustion, a quantity of oxygen ; while the latest innovations comprise attempts, made with varying degrees of success, to utilize directly the lighter oils obtained in the rectification of petroleum.

It may not be generally known that the introduction of coal-gas was attended with unusual difficulties. The most vehement protests were proclaimed and circulated denouncing its introduction. It was characterized as eminently dangerous, impractical and injurious to health. It was only when time had demonstrated the groundlessness of some of the objections urged against it, and the gross exaggeration of others, and after the ingenuity of invention had shown how the dangers attending its use could be met and averted with ordinary prudence, that objectors were silenced, and the new light grew rapidly into popular favor. It is sincerely to be hoped that it will not prove otherwise with the light products of petroleum. The light which they emit is brilliant and beautiful, and, what is quite as important, the supply is practically inexhaustible ; the demand for them in various technical operations is scarcely able to keep pace with the present supply—and should a new field for their utilization on a large scale be opened up, this supply could be greatly increased. With such possibilities, therefore, in our inventive era, the discovery of safe and economical devices by which these products of such valuable light-giving properties may be utilized for the purposes of illumination, for which nature has eminently fitted them, is manifestly but a question of time.

That the importance of the subject is duly appreciated by the practical mind of the country, is amply evidenced by the records of the Patent Office, by which it will be seen that the number of processes secured for devices suitable for the utilization of these light petroleum oils reaches several hundred. These may all, however, for the purpose of classification, be included under two underlying plans or systems.

In one of them, hydrogen gas is generated by some one of the methods suitable for the purpose, and this, by a suitable arrangement is made to pass through or about the light oils, the utilization of which

is to be effected. By this contact and the attendant mechanical agitation, the oil in each case is partially converted into vapor, which is carried along with the current of hydrogen in mechanical suspension. In this condition it is ignited, the illuminating property of the mixture being entirely dependent upon the oil vapor, since of itself hydrogen gas gives a non-luminous flame.

The second plan includes numerous mechanical devices by which a current of air, kept either at the common temperature, or heated by an external fire in order to facilitate the formation of vapor is drawn over or through a well of the oil. The air, like the hydrogen in the former plan, becomes surcharged with vapor, and in this condition is utilized.

Finally, the latest plan for illumination which has been published, consists in mixing ordinary burning gas with a certain proportion of air, and forcing the ignited mixture upon platinum sponge. The latter, by arresting and appropriating the luminous vibrations of the combining gases, becomes a brilliant point of light.

We have now before us, in some detail, all the processes of sufficient importance to warrant mention, which go to make up the history of the interesting subject of illumination. The peculiarities and the merits of these several plans will be our next consideration.

Burning Gas from Coal.—One of the most important discoveries which has been made in connection with the subject of artificial illumination, is the process of manufacturing and utilizing the gaseous products obtained in the distillization of bituminous coal. These utilizable illuminating products consist of the so-called light and heavy carburetted hydrogen—the same gases to which the candle and the torch owe their efficiency. The only difference in the comparison consists in the fact that, with the coal gas, we store up the combustible gases for future consumption, while with the candle or torch we produce these gases during the act of burning. The heat developed by the burning of one set of gaseous particles from the wood, is sufficient to generate in the woody fibre immediately adjacent, more of these gases; these, by their combustion repeat, the process, and this continues until all is consumed.

It cannot be doubted that the utilization of illuminating gas from coal is the most important discovery in technical chemistry with which the present century may be credited. Both directly and indirectly it has immensely benefitted mankind. A well-known writer sums up its advantages in terms nearly as follows:

"It has furnished us with a light so pure and steady, and of such cheapness, that those engaged in manufacturing pursuits may carry on their labor far into the night with little inconvenience and cost. It has drawn into more useful channels the brain and muscle of thousands formerly engaged in procuring from the soil or sea the oils then universally consumed in its stead. In a sanitary point of view it is far superior to its predecessors, both in point of cleanliness and in the absence of offensive smells from its combustion. Whether we view it from the commercial standpoint and estimate the increased wealth which has resulted from its introduction in every branch of trade and industry, or as a civilizing agent, which has added to the comfort, health and luxury of millions, the introduction of coal-gas ranks second to none of the discoveries of our times."

Petroleum.—On many portions of the earth's surface abundant springs of an oily fluid exist. These occur at times associated with indurate or semi-solid resinous matters called by various names, such as bitumen, mineral pitch, asphaltum, &c., which are now known to be the residuum left behind by the oils on their exposure to the air. These oils, whether occuring in Persia, on the shores of the Caspian Sea, or in our own country, all possess the same general properties, a fact which points strongly to the belief that they have originated under very similar conditions. The general horizon of the rocks from which the supply of the oil proceeds is in the neighborhood of the coal measures; but this is by no means universally the case, for it has been found in abundance in formations both older and more recent than those belonging to the coal-bearing series. But, whatever the nature of its occurrence, the peculiar character of the material leaves but little room to doubt the fact that it is a product of the slow decomposition, perhaps distillation of vegetable or animal matter or both. Though some differences of opinion may still exist in connection with the process of its origin, the organic nature of its formation has never been called into dispute.

The supply of this oil, especially in our own vicinity, seems to be practicably inexhaustible; but though this fact appears to have been known to some, no organized movement to utilize it appears to have been made, except locally, until within quite a recent period—less than twenty years.

When once its value as an illuminating agent became known, its introduction for the purposes of the household followed with great rapidity. In a few years an important and constantly increasing in-

dustry sprung up in the oil producing regions, which, offering unusually favorable opportunities for speculative enterprises, created a furore amongst men of every stamp, which received the happy sobriquet of the "oil fever." But despite the wide-spread commercial misfortunes which followed in the train of speculation, and which earned for many participators a questionable reputation for integrity, the value of the oil became more generally understood, and the demand for it increased to such an extent that to-day the growth of the industry engaged in its production is beyond comparison with any other.

This statement will, perhaps, be realized when it is declared that in the year 1870 there were, in the Pennsylvania region alone, more than 3000 productive wells, while the yield of the United States and Canada for the same year is estimated by careful statistics to have reached the enormous figure of 6,500,000 barrels.

As the chemical and physical properties of the oil petroleum may not be generally known, it is proposed to give, in as brief a space as possible, a description of them.

The crude oil, as it is sought from the wells, is of a variable color, but generally greenish or brownish in tint, possessing an unpleasant odor resembling that of bitumen. It is somewhat lighter than water, its specific gravity, though varying with locality, being about 0·85, water being taken as 1.

When heated, however, the curious fact is brought to light that, instead of being a simple homogeneous substance, the oil is composed of a great number of compounds very similar in their chemical character, but differing in their densities and in their boiling points.

In virtue of the last named property, the manufacturer is enabled, with the aid of well-regulated heat, to separate these numerous compounds from each other. The process here indicated is known as fractional distillation, and is always resorted to where it is desired to separate the ingredients of a mixture which have no destructive chemical action on each other, but which happen to have different boiling points. The mixture is placed in a suitable retort, connected with a cool condensing vessel, and a gradually increasing heat is applied until one of the components begins to distil over. The heat is then kept constant at this point until the distillation ceases. This is a proof that everything capable of boiling at that temperature has been removed and collected. The heat is then gradually elevated until signs of distillation are again observed; at this temperature it is re-

tained until the second distillate is collected; and so on until all the components have been separated.

Such is the general character of the process, then, which applied to the crude oils we have been describing enables the manufacturer to split them up into a number of useful substances; some of which, as being especially interesting, will shortly be described.

It is, however, necessary to add that the description above given is not absolutely correct, though in principle it is so, when applied to the processes adapted on the commercial scale for the rectification of petroleum.

The reason for this imperfect separation is that the crude oil is made up of so many, the boiling points of which lie very close to each other, that it is found in practice impossible to regulate the temperature of the crude material with sufficient nicety to separate the mac-curately. So that each of the commercial products to which custom has attached a certain name, must not be understood to be a simple oil, but to be, perhaps, an intimate mixture of a number of them. The plan practice has determined to be the best for the purpose of describing which these commercial products is that of stating the extremes of the thermometric scale within which each has been collected. The statement of the density or specific gravity of the commercial products is met with oftener than that of the boiling point. This plan of designation must, however, not be looked upon as distinct from the one above stated, for it is simply a convenient mode, of which the manufacturer avails himself, of estimating nearly enough for practical purposes, the distilling temperature of a commercial oil. Seeing that the boiling point of each individual product stands in a well known rate to its density—the heavier the oil the higher its boiling point, and *vice versa.*

The advantage of this plan lies in its convenience. In commercial operations an attendant, from time to time, plunges the hydrometer into the distillate, until he perceives that it registers an oil of the desired weight. When this occurs the distillate is led into another collecting vessel, where a similar operation is conducted for a heavier oil than the first, and so on until all the operations are completed. By this process then the following products are obtained from the crude petroleum. The average gravity, for each of the products named, are those most generally accepted, there being, as far as our knowledge extends, no strict scientific division applicable to their definition:

Name.	Gravity.
Rhigoline, ...	
Gasoline, ...	85.
Naphthas, ...	65 to 70.
Burning Oils, ...	45.
Paraffin Oils, ...	Below 38.
Paraffin, Residuum, }	Solid.

Of these products the first and the last three do not concern us directly, though a mention of their applications may not be uninteresting.

Rhigoline, which is the first product upon the list of oils, is an exceedingly light, limpid liquid, which evaporates quite rapidly when exposed to the air. It is used to some extent in surgical operations as a styptic, and constitutes generally about one per cent. of the crude material.

The heavy oils from which the solid paraffin is extracted are found very suitable, after chemical preparation, for the lubrication of certain parts of machinery, but beyond this they are of no interest. From the residuum the valuable color yielding products, in which the residues of the gas manufactories are so rich, have been obtained. With paraffin and its many important applications in the arts the intelligent reader is already familiar.

The burning oils are those which are now very generally used for household purposes in portable lamps. The naphthas, though largely used to adulterate the burning oils, is entirely unsuited and even dangerous, for reasons to be more fully stated hereafter, when used in the lamps constructed for the purpose of consuming the burning oils. Indeed a large proportion of the accidents arising from the use of petroleum is clearly attributable to this source of danger. Its proper utilization thus far has been confined mainly to a variety of processes in manufacturing. The few legitimate attempts, as yet announced, for applying this product for illuminating purposes have been those in which an apparatus specially designed for the purpose has been constructed. And there is little doubt but that, should it be found profitable to compete with this material against the illuminating agents which at present fully occupy the field, a number of plans could be devised by which it could be burned with any desirable amount of safety.

The gasoline, forming about 6—8 per cent. of the crude material, is

in appearance identical with the product just considered, and differs only in its gravity and its more ready volatility. It has many industrial applications similar to those of the naphthas, and is now, to some extent, used as an illuminating agent, the abundant supply of the material as well as the excellent light it affords having given origin to numerous plans for its combustion.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Meeting, Dec. 20, 1871.

The meeting came to order at the usual hour, the President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers and the reports of the several Committees. No donations were reported for the library.

The Committee appointed to examine and report upon the question of rating Steam Boilers, reported progress, and were continued.

The President appointed Messrs. Orr, Rollin, Hoskins, J. H. Cresson, Rand, Gardom and Mason as Judges of Election for the year 1872.

The following nominations for officers for the ensuing year were made:

President.—Coleman Sellers.
Vice-President.—B. H. Moore.
Secretary.—William H. Wahl.
Treasurer.—Frederick Fraley.

Managers to serve three years.—Washington Jones, Pliny E. Chase, Charles S. Close, J. M. Wilson, William P. Tatham, Dr. Isaac Norris, Jr., Robert Briggs, William P. Durfee.

To serve two years.—Edwin J. Houston.

For Auditor.—Samuel Mason.

The Secretary's Report upon Novelties in Science and the Mechanic Arts was read, upon which the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, Jan. 17, 1872.

The meeting was called to order by the President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the meeting held January 17th, 1872, the following donations had been made to the library:

From the Royal Astronomical Society, and Royal Geographical Society, of London, England, Smithsonian Institution, Washington, D. C.

The judges of election reported the following gentlemen elected as officers of the Institute for the year 1872:

President.—Coleman Sellers.
Vice-President.—B. H. Moore.
Secretary.—William H. Wahl.
Treasurer.—Frederick Fraley.

Managers to serve three years.—Washington Jones, Pliny E. Chase, Charles S. Close, J. M. Wilson, William P. Tatham, Dr. Isaac Norris, Jr., Robert Briggs, William P. Durfee.

To serve two years.—Edwin J. Houston.

For Auditor.—Samuel Mason.

The report of the Committee on memorial to the late Actuary, Mr. Hamilton, was read, and subscriptions reported.

The Secretary then read his report upon Science and the Mechanic Arts, when the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

New Method of Observing the Sun's Rotation.*—Zöllner and Vogel have succeeded in making measurements of the velocity of the sun's rotation with the spectroscope. The method pursued is too elaborate to be described in a brief notice. The value obtained for the motion of a point on the sun's equator is 0·42 German miles per second from one series of observations, and 0·35 miles from a second series. These values are somewhat greater than those at present received. As a new application of the spectroscope, optically demon strating the fact of the sun's rotation, these experiments are of much interest.

* Pogg. Ann. cxliv, 449.

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